NASA CR- 143672

EARTH OBSERVATORY SATELLITE SYSTEM DEFINITION STUDY

REPORT NO. 5: SYSTEM DESIGN AND SPECIFICATIONS

• Part 2: Ground System Element Specifications

(NASA-CR-143672) EARTH OBSERVATORY SATELLITE SYSTEM DEFINITION STUDY. REPORT NO. 5: SYSTEM DESIGN AND SPECIFICATIONS. PART 2: GROUND SYSTEM ELEMENT SPECIFICATIONS (Grumman Aerospace Corp.) N75-15718 Unclas G3/18 09255

GRUMMAN

EARTH OBSERVATORY SATELLITE SYSTEM DEFINITION STUDY

REPORT NO. 5: SYSTEM DESIGN AND SPECIFICATIONS

• Part 2: Ground System Element Specifications

Prepared For

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NAS 5-20520

October 1974

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NOTE

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ABBREVIATIONS AND ACRONYMS

AHDDR	Acquisition High Density Digital Recorder
APDEL	Applications Program Development Laboratory
CCT	Computer (industry) Compatible Tape
CDPF	Central Data Processing Facility
CI	Configuration Item
CPS	Central Processing System
DPSK	Differentially encoded PSK
DRHS	Data Recording and Handling Subsystem
EOS	Earth Obseravtory Satellite
GCP	Ground control point
GHz	Gigahertz
GSE	Ground System Element
HDDT	High Density Data Tape
HDDR	High Density Data Recorder
IF	Intermediate frequency
ISS	Information Services System
LDEL	LUS Diagnostic and Equipment Laboratory
LRM	Land Resource Mission
LUS	Local User System
MISCON	Mission Control
MSS	Multispectral Scanner
NRZ	Non-return-to-zero
PCC	Project Control Center
PGS	Primary Ground Station
PSK	Phase shift keying
QDSC	QPSK Demodulator & Signal Conditioner
QLM	Quick Look Monitor
QPSK	Quadriphase shift keying
RF	Radio frequency
SCPS	Support Computer Programming System
SF	Status Formatter
SHF	Super high frequency
ST	Switching Terminal
STDN	Spaceflight Tracking & Data Network

ABBREVIATIONS AND ACRONYMS (Cont)

TBD	To be determined
TDRSS	Tracking & Data Relay Satellite System
TM	Thematic Mapper
UTM	Universal transverse mercator

1 - SCOPE

This specification establishes the performance, design, and quality assurance requirements for the Earth Observatory Satellite (EOS) Observatory and Ground System program elements required to perform the Land Resources Management (LRM) "A" mission. The specification is divided into two parts. Part 1 contains requirements for the Observatory element with the exception of the Instruments Specifications which are contained in Report 2 of the EOS System Definition Study.

Part 2 contains the Ground System requirements for the LRM A and B missions. Specifications for the R&D instrument (Thematic Mapper) data processing are provided (LRM A Mission). Additionally, the specifications cover the R&D Instruments (Thematic Mapper and High Resolution Pointable Imager) data processing for the LRM B Mission. Because the overall program approach is "Design to Cost," cost targets for each of the EOS program elements are identified.

2 - APPLICABLE DOCUMENTS

The following documents of the latest issue form a part of this specification to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this specification , this specification shall be considered a superseding requirement.

2.1 GOVERNMENT DOCUMENTS

SPECIFICATIONS

Military

MIL-E-4158E	Electronic Equipment, Ground, General Requirements for
MIL-F-7179	Finishes and Coatings, General Specifications for Protection of Aerospace Weapons System, Structures and Parts
MIL-T-21200	Test Equipment for Use with Electronic and Electrical Equipment, General Specification for
MIL-S-8512	Support Equipment, Aeronautical, Special, General Specification for the Design of

STANDARDS

Military

MIL-STD-454	Standard General Requirements for Electronics Equipment
MIL-STD-461	Electromagnetic Interference Characteristics, Requirements, for Equipment
MIL-STD-130	Identification Marking of U.S. Military Property
MIL-STD-1472	Human Engineering Design Criteria for Military Systems, Equipments, and Facilities

GSFC

STD-256-4	"Preparation of Operation and Maintenance Manuals"

2.2 GRUMMAN DOCUMENTS

SPECIFICATIONS

GSS 4710-1	Identification and Marking of Fabricated Metallic Parts

SPECIFICATIONS (cont)

GSS 4711	Identification and Marking of Non-Metallic Parts and Assemblies
659001	Workmanship Standards Drawing

2.3 OTHER DOCUMENTS

SPECIFICATIONS

STDN No. 101.1 May 1974, Rev. B	User's Guide Baseline Document
NASCOM FY74-1 Rev. 9	Data Systems Development Plan
MM-4287, Interface Control Document	Spacecraft Tracking and Data Network Technical Manual - Digital Data Processing System
GSFC-S-533-P-11A	Grounding Systems Requirements for STADAN Stations
NASA NBH 5300.4 (3A)	Requirements for Soldered Electrical Connections
TM-5-241-8	Dept. of the Army Universal Transverse Mercator Grid

2.4 EOS PROGRAMMING DOCUMENTS

SPECIFICATIONS

EOS Mission Operations Plan (TBD)

EOS Observatory System Element Specification (Part 1, Report 5)

2.5 NON-GOVERNMENT DOCUMENTS

SPECIFICATIONS

X3.22 - 1973	ANSI Recorded Magnetic Tape for Information Interchange (800 CPI, NRZI)
X3.39 - 1973	ANSI Recorded Magnetic Tape for Information Interchange (1600 CPI, PE)
X3B1 - 658	ANSI Recorded Magnetic Tape for Information Interchange (6250 BPI, Group Coded) (Proposed)
X3.29 - 1969	ANSI Magnetic Tape Labels for Information Interchange

SPECIFICATIONS (cont)

X3.4 - 1968	ANSI Code for Information Interchange
X3.5 - 1970	ANSI Flowchart Symbols
X3.9 - 1966	ANSI Fortran
X3.23 - 1968	ANSI Cobol

3 - REQUIREMENTS

3.1 SYSTEMS DEFINITION

The general design objective of the Earth Observatory Satellite Program is to provide a flexible, cost effective facility for conducting a broad range of earth remote sensing missions. The facility will consist of a general purpose, or standard spacecraft capable of accommodating a wide variety of instruments, and all ground data acquisition and processing systems necessary to provide data directly to the users.

3.1.1 PROGRAM DRIVER REQUIREMENTS

The top level program driver requirements are as follows:

- The EOS System shall provide a basic capability to perform Land Resources Management (LRM) missions and shall be adaptable, with minimum modifications, to at least the following missions:
  - Marine and Water Resources and Pollution
  - Ocean Dynamics and Sea Ice
  - Weather and Climate
  - Solar Observation
  - Stellar Observation
  - Inertial Pointing (EGRET)

  A typical mission model comprising these missions is shown in Fig. 3-1.

- The EOS System design for LRM shall accommodate combined operational and R&D functions. Consideration shall be given to the integration of hardware and coordination of operations for this dual program relationship.

- The Basic Spacecraft shall be modular and standardized for the range of missions described. Specialized Mission Peculiar Equipment shall be provided above the interface of the Basic Spacecraft. The Basic Spacecraft contains three basic subsystem modules; 1) Altitude Control, 2) Communications and Data Handling, and 3) Electrical Power. A fourth module, Orbit Adjust/Reaction Control, is Mission Peculiar. Other Mission Peculiar equipment includes the instruments, wideband data processing and communications hardware and orbit transfer modules.

- The EOS Observatory shall be designed to utilize the Shuttle for economic and operational benefits. Capability for incorporating Shuttle retrieval and in-orbit resupply provisions shall be provided.

- Earth scanning revisit cycle for LRM missions shall be a maximum of 17 days. A design goal of 6-9 days revisit cycle should be considered.

- Data turn-around time for LRM missions shall be 24-48 hours. Turnaround time is defined as from time of receipt at the earth-based receiving station to time of transmittal to the user.

- Basic LRM data processing (output products) shall be digital. Data products shall include Computer Compatible Tapes and High Density Digital Tapes, black and white, and color images. Output products are required for up to 100 generic users. Central processing throughput rate shall be capable of handling a minimum of 10^{10} bits per day and shall be expandable to as much as 10^{12} bits per day. Black and white prints and color film and prints will be produced by the existing ERTS Photographic Laboratory. The Photo Lab is treated in this specification only as an external interface to the Central Data Processing Facility.

- LRM imaging and data acquisition shall be primarily of continental United States (CONUS). Capability shall also provide for International Data Acquisition (IDA) via TDRSS. Provisions shall also be made for optional on-board tape recorders to accomplish IDA.

- EOS payload data shall be radiometrically and geometrically corrected (with and without GCPs) before delivery to the data users. An option shall be provided to allow the user to obtain radiometrically corrected data together with geometric correction information sufficient to perform any further geometric corrections.

- The EOS system for LRM, and the Basic Spacecraft shall each be designed to a target cost.

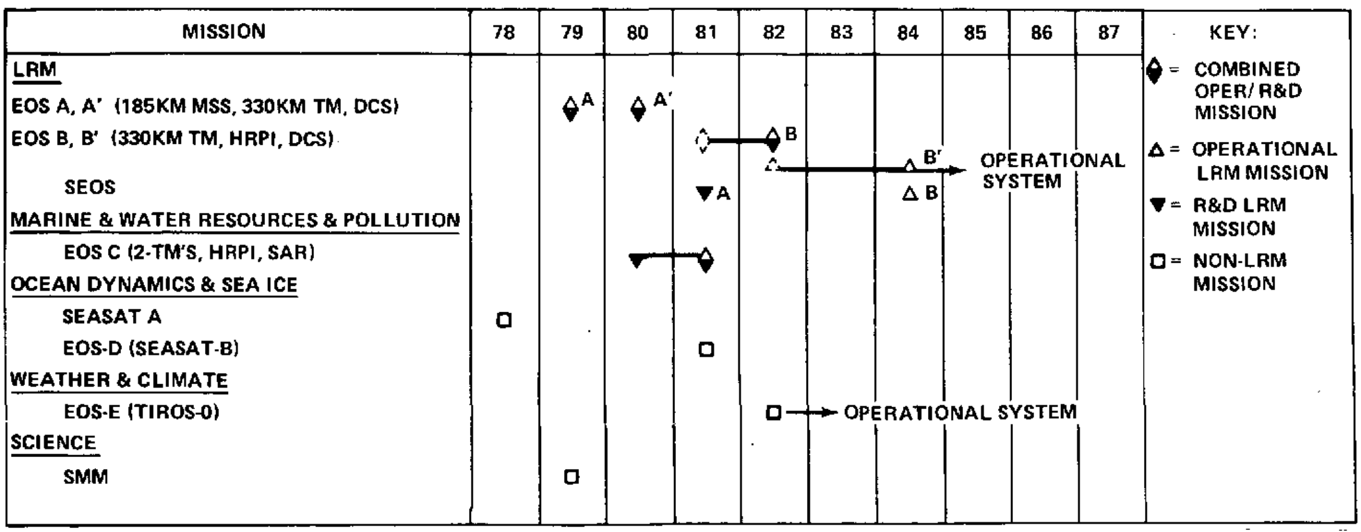

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Fig. 3-1 Typical Mission Model

3.1.2 GENERAL DESCRIPTION

3.1.2.1 PROGRAM SEGMENTS

The Ground System is one element of the Earth Observatory Satellite System. The total system is illustrated in Fig. 3-2 and is composed of the Launch Vehicle, Observatory, Primary Ground Stations, Local User Systems, Control Center, Central Data Processing Facility, and the Support Equipment. The Program Functional Areas are defined in Fig. 3-3.

3.1.2.2 GROUND SYSTEM ELEMENT

The Ground System Element (GSE) of the Earth Observatory Satellite Program is composed of several subelements (systems, subsystems, etc.). These subelements are interconnected to provide a means of controlling and monitoring the space element (Observatory System Element) and to provide a means of acquiring, recording, conveying, and processing EOS payload data to make them of use to EOS data users. Communication and ancillary processing of control and scheduling data both within and without the ground element shall be effected by the GSE in order that the ground and space elements shall operate as a system.

As a minimum, the GSE shall provide two complete and independent data systems in all respects, except for the centralized control thereof that shall be caused through the Information Services System, a subsystem of the Central Data Processing Facility (CDPF). Interconnection of the major systems and the flow of data and control between them are indicated in Fig. 3-3.

The primary flow of payload data through the GSE is initiated by the acquisition of the data at the Primary Ground Stations (PGSs) unless the Tracking and Data Relay Satellite System (TDRSS) shall be considered to replace the PGSs. In either event the acquired payload data shall be rapidly transferred to the CDPF. The components of the CDPF are shown in Figure 3-3A and are defined in the following paragraphs. Data processed by the Central Processing System (CPS) shall be delivered to the primary data users.

A secondary flow of payload data is initiated by data acquisition at Local User Systems (LUSs) also known as Low Cost Ground Stations. The LUS shall be capable of operating independently of other GSE units, except the ISS which shall, at a minimum, provide a means to supply the LUSs with Observatory pointing data required by the LUSs to direct the LUSs pointing antennas for data acquisition. The LUS shall process payload data as they are processed within the CDPF, and shall provide an analysis capability not a part of this specification.

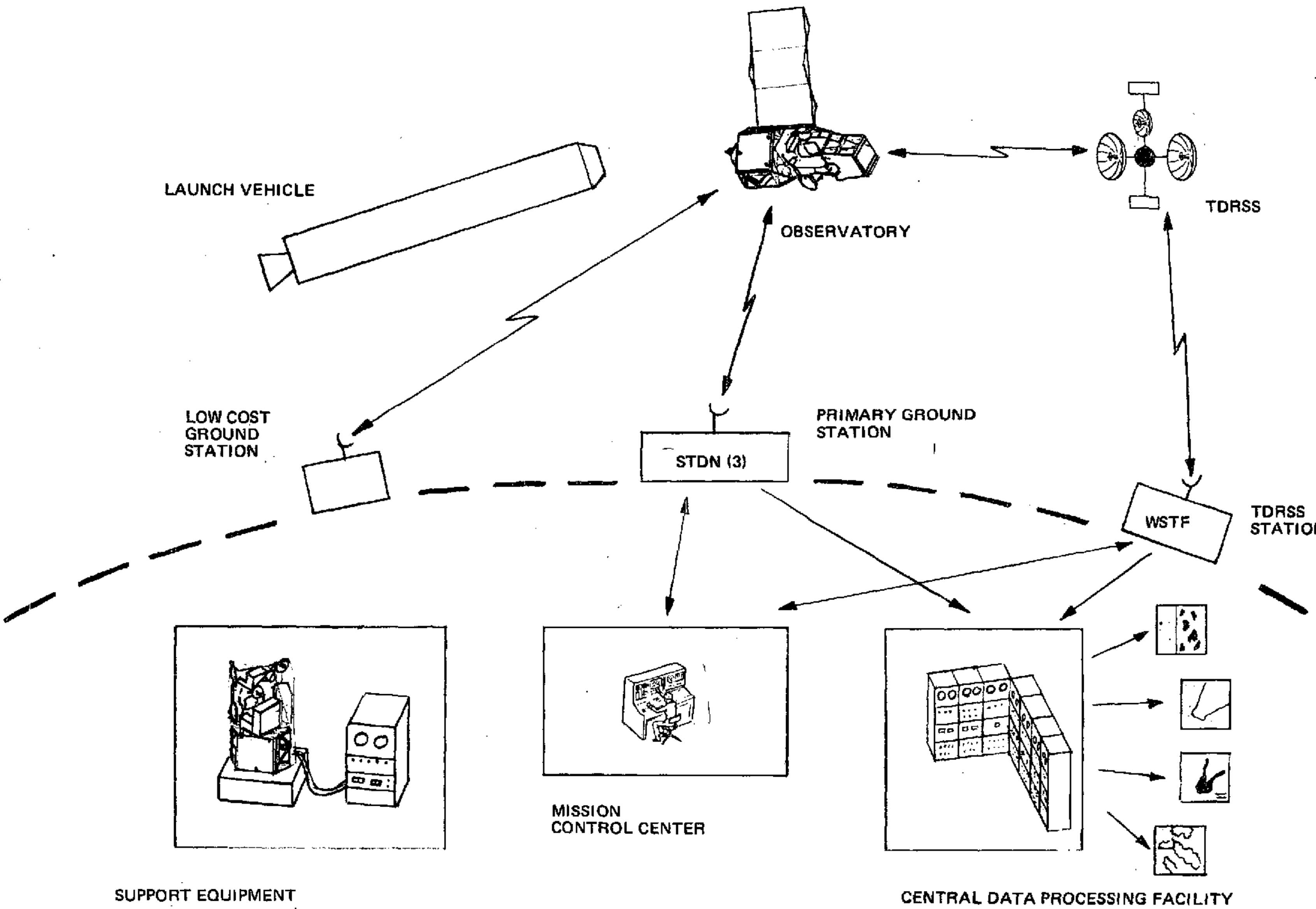

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Fig. 3-2 Earth Observatory Satelite System Program Segments

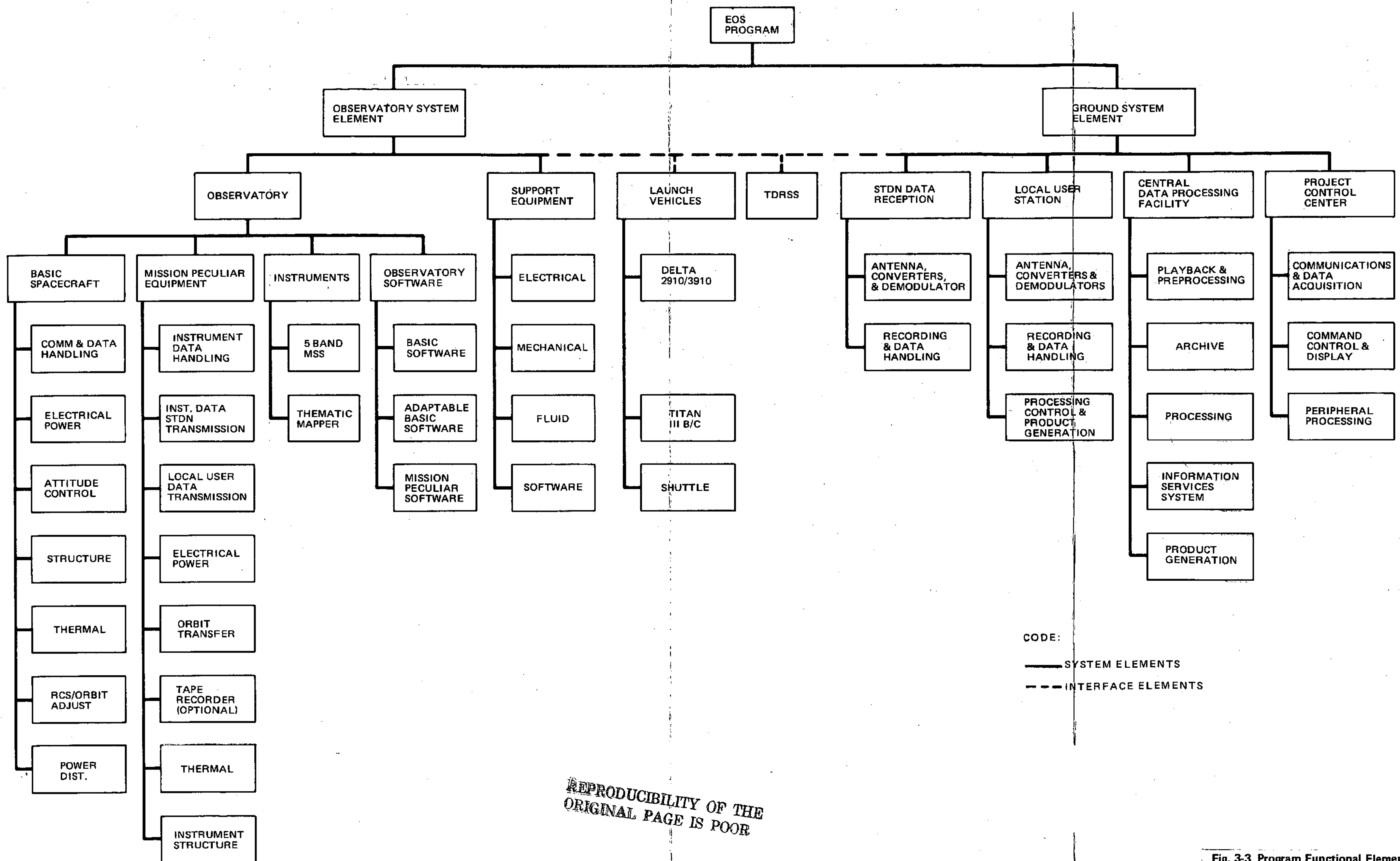
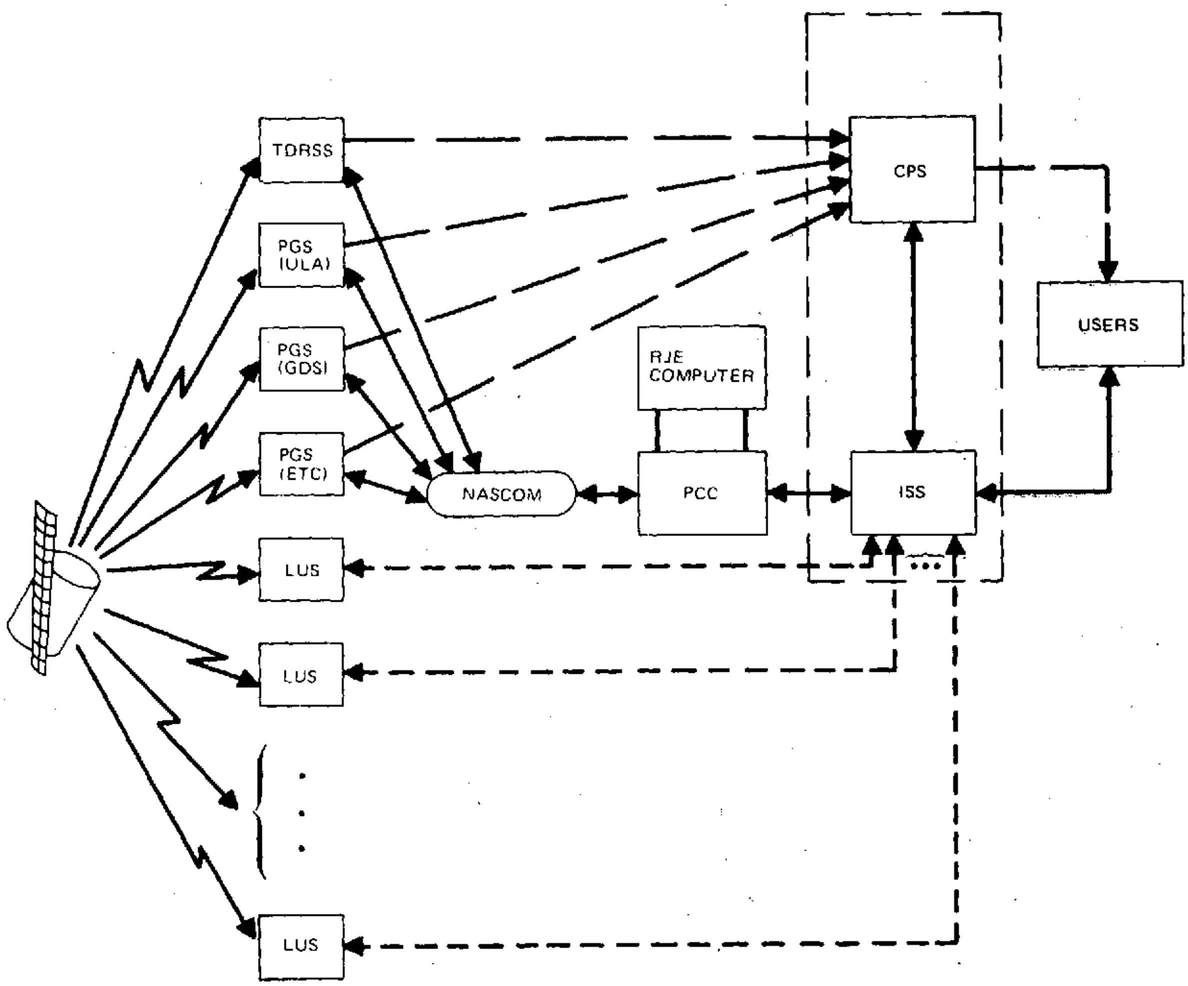


Fig. 3-3 Program Functional Elements



SPACECRAFT PAYLOAD DATA
CONTROL DATA & INFORMATION
INFORMATION & SERVICES DATA

PGS–PRIMARY GROUND SYSTEM
LCS–LOCAL USER SYSTEM (INCLUDES THE LOW COST GROUND STATION)

RJE–REMOTE JOB ENTRY
ISS–INFORMATION & SERVICES SYSTEM
CPS–CENTRAL PROCESSING SYSTEM
PCC–PROJECT CONTROL CENTER
EOS–EARTH OBSERVATORY SATELLITE
NASCOM–NASA COMMUNICATIONS
TDRSS–TRACKING AND DATA RELAY SATELLITE SYSTEM

DATA COMMUNICATIONS, RECORDING, CONTROL, PROCESSING, AND INFORMATION SERVICES

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Fig. 3-3A EOS Data Management Concept

The CDPF is to be located at GSFC, and provides a means through the ISS and PCC of performing all scheduling functions and the control thereof to the Observatory and the ground element. The ISS shall also control the CPS and provide a means for the primary data users to order data products and obtain status of their requested products.

3.1.2.3 PAYLOAD DATA RECEPTION, RECORDING, AND HANDLING

Reception of the data transmitted from the EOS occurs at three types of facilities:

- Primary Ground Stations
- Local Users
- Tracking and Data Relay Satellite System (TDRSS) Ground Station

The primary ground stations are three members of NASA's Spaceflight Tracking and Data Network (STDN), specifically the super high frequency (SHF) portions of ground terminals located at:

Engineering Test Center (ETC), Greenbelt, MD.

Goldstone (GDS), California.

Fairbanks, Alaska (ULA).

The function of this portion of the system is to receive the SHF signals transmitted by the EOS, demodulate the signals, and record, or handle the data derived, for further processing by the Central Processing System. Data received via the TDRS System is transmitted by terrestrial or communications satellite network to the CDPF.

Elements of the Primary Ground Stations (PGS) include the following subsystems:

- Antenna and feed
- Parametric Amplifier
- Receiver/Downconverter
- Demodulator
- Antenna Mount
- Antenna Tracking and Pointing Subsystem
- Data Recording and Handling Subsystem.

The antenna, its mount, and the tracking and pointing subsystem will be Government-furnished (existing STDN terminal equipment) and are not addressed further in this document.

3.1.2.4 CENTRAL DATA PROCESSING FACILITY

The Central Data Processing Facility (CDPF) accepts image and auxiliary data from the acquisition recorders and supplies output products to the users. The CDPF consists of the ISS and the Central Processing System (CPS). The CDPF shall include the following subsystems:

- Appropriate data input equipment together with any preprocessing necessary to achieve compatibility between the acquisition storage medium (tape) and the remainder of the system.
- A means for achieving both input and processed data for subsequent retrieval for further processing or dissemination to users.
- A processing subsystem that performs radiometric calibration and geometric correction of the image data.
- An information services subsystem which provides overall internal control of the CDPF, acts as the primary user interface for data selection and product requests, and performs additional functions such as scheduling, cataloging, and quality control for the CPS.
- A product generation subsystem that prepares digital and photo products from the processed data.

Two central processing systems are discussed in this specification: An Initial CPS (ICPS), and a Final CPS (FCPS). The ICPS shall contain provisions for phased growth to a system satisfying the increased throughput requirements of the FCPS. The CDPF shall have sufficient ancillary hardware and software capability to support software development and modification.

3.1.2.5 PROJECT CONTROL CENTER (PCC)

3.1.2.5.1 PCC Functional Summary

The PCC is responsible for controlling the operation of the EOS spacecraft on orbit. This responsibility includes:

- Mission planning, which entails the coordination of all requests (user and engineering) for EOS operations, and the supervision of the development of contact messages.
- Mission operations, which entails all real time monitoring and control functions necessary to preserve the health of the Spacecraft and to operate efficiently.
- Mission analysis, which entails reviewing all historical aspects of the mission for the purpose of failure/anomaly analysis, studies of normal S/C performance, and the development of improved operating procedures.

3.1.2.5.2 PCC CONFIGURATION SUMMARY

The PCC shall consist basically of three functional areas:

- Communication and Data Acquisition Area (front end)
- Command Control and Display Area
- Peripheral Processing Area.

The Communication and Data Acquisition area shall perform the following functions:

- Receive downlinked telemetry housekeeping data via the NASA data acquisition facilities and NASCOM and monitor it for quality
- Condition the signals so that all have known characteristics
- Perform bit synchronization, frame synchronization and subframe synchronization of the serial data stream
- Preprocess the data and make it available to the other areas
- Receive coded command messages from the command control and display area and transmit them to the spacecraft NASCOM network
- Provide recording facilities to permit satellite housekeeping data to be stored for future play back and evaluation.

The command control and display area shall perform the following functions:

- Provide display facilities to permit Project Control Center (PCC) personnel to visually determine the status of the Spacecraft by evaluating the housekeeping data
- Generate the commands necessary to operate the Spacecraft and its payload as follows:
    - Compile commands which satisfy the activity plan within spacecraft capabilities.
    - Display and verify commands before transmission
    - Block and format commands and transmit via the appropriate network
    - Verify both realtime and catalogued command execution.
- Interface with the ISS to receive user data requests and provide ephemeris points for payload data reduction correlation
- Interface with the NASA/GSFC Orbit Determination Facility to receive EOS ephemeris data
- Interface with the NASA/GSFC MISCON to determine the ground contact profile for the EOS

- Interface with the NASA/GSFC SCPS to receive EOS contact messages and AOP updates.

The Peripheral Processing Area shall perform the following functions:

- Produce hard copy outputs of selected data items in form of snapshot prints, plots, and strip chart recorders
- Provide a means to develop new programs both system and maintenance.

3.1.2.6 LOCAL USER SYSTEM

The Local User Systems (LUS) are complete ground station and data processing systems that permit users to access the Observatory on a receive only basis, acquire, and process data independent of the CDPF except for the transmission of a limited set of antenna pointing information. The LUS consists of:

- X-band antenna
- Programmed tracking system
- Low-noise preamplifier
- Receiver and downconverter
- DPSK demodulator and signal conditioning subsystem
- Data recording and decommutation subsystem
- Processing and display subsystem.

The data transmitted to the LUS will be a reduced resolution or coverage subset of the data transmitted to the PGS.

3.1.3 PROGRAM COSTS

Costs shall be considered as a major design requirement for the EOS program. Cost targets shall be established for the total EOS program, and for each EOS program element.

Individual performance requirements defined in this specification, lower level performance requirements and management requirements may be traded, within overall EOS System performance requirements, to achieve the specified element cost targets.

The specific cost targets for the Observatory and Central Data Processing Elements of the EOS "A" system defined in this specification are as follows:

EOS ELEMENT	BASIC SPACECRAFT		LRM "A" MISSION	
	NON REC	REC	NON REC	REC
Basic Spacecraft	18.0 M	5.5 M	20.0 M	6.9 M
Spacecraft LRM "A" Mission Peculiars. (R&D Miss.)	------	------	4.8 M	1.9 M
Spacecraft LRM "A" Mission Peculiars. (Operational Miss.)	------	------	4.0 M	2.9 M
TOTAL EOS "A" Observatory Cost	------	------	28.8 M	11.7 M
Central Data Processing (R&D Miss.)	------	------	11.8 M	------
Central Data Processing (Operational Miss.)	------	------	11.6 M	------
Note: Launch costs, etc. are not included.				

3.1.4 MISSIONS

3.1.4.1 LAND RESOURCES MANAGEMENT (LRM) MISSION A

The Observatory and Ground System shall support the LRM mission

3.1.4.1.1 Mission Objectives

Development instruments, data processing and other spacecraft systems to acquire spectral measurements and images suitable for generating thematic maps of the earth's surface.

Operate these systems to generate a data base from which land use information such as crop or timber acreages or volumes, courses and amounts of actual or potential water run-off and the nature and extent of stresses on the environment will be extracted.

Demonstrate the application of this extracted information to the management of resources such as food and water, the assessment and prediction of hazards such as floods, and the planning regulation of land use such as strip mining and urbanization.

3.1.4.1.2 Mission Description

The basic requirement of the LRM instruments is repeating earth coverage under nearly constant observation conditions. This requires a circular sun synchronous orbit with an integral number of orbits and days per repeat ground trace pattern. A solar orbit of 98^{o} inclination with an orbital altitude of 365 to 385 n mi and descending node time of day ranging from 9:30 AM to 11:30 AM, meets these requirements.

Instrument data shall be transmitted from the observatory via RF links to ground stations and forwarded to the data processing facility for processing. Data products, both photographic and computer compatible will be produced for transmittal to the User community.

The following instruments in various combinations are planned for the LRM missions: 5-Band Multi Spectral Scanner, Thematic Mapper, High Resolution Pointable Imager.

3.1.4.2 FOLLOW-ON MISSIONS

The Observatory System shall be capable of accommodating follow-on missions.

3.1.4.2.1 Land Resources Mission B

These satellites are the operational version of LRM-A. The instruments to be installed are the Thematic Mapper and the High Resolution Pointable Imager.

3.1.4.2.2 Land Resources Mission C

This Observatory is another operational version of LRM-A. It will provide data for the evaluation of marine and water resources and pollution by utilizing two TM's, a HRPI and SAR.

3.1.4.2.3 SEASAT A

3.1.4.2.3.1 Mission Objectives

The SEASAT-A mission is designed for development and demonstration of space techniques for forecasting and monitoring sea state currents, circulation, pileup, storm surges, tsunamis, air/sea interactions, surface winds, and ice formations.

3.1.4.2.3.2 Mission Description

Nominal circular orbital altitude of 391 n mi (725 Km) at an inclination of 82°.

3.1.4.2.3.3 Instruments

Instruments planned for this mission are active and passive microwave facilities and an infrared/visible imager.

3.1.4.2.4 Solar Maximum Mission (SMM)

3.1.4.2.4.1 Mission Objectives

The SMM is a low earth orbit solar pointing satellite designed for solar observations during the period of maximum solar activity (expected on or about 1978). Its general mission objective is to make solar observations in all areas of the spectrum from IR to gamma rays and obtain data to supplement data acquired during the SKYLAB/ATM mission. The SMM will serve specific applications in the fields of: solar flares, flare-associated X and gamma radiation as well as high energy particles, solar interior to corona energy transfer, solar and stellar evolution.

3.1.4.2.4.2 Mission Description

Initial launch is scheduled for June/78 on a Delta launch vehicle. Subsequent retrieval and redeployment is planned for Shuttle. Minimum orbital life is 1 year. The nominal orbit is 275-300 n mi circular at an inclination of 28-33^{o}.

3.1.4.2.4.3 Instruments

The instrument payload of SMM is made up of X-ray and UV Spectrometers, Spectroheliographs (images), Spectrographs, and a Coronagraph.

3.1.4.2.5 Synchronous Earth Observatory Satellite (SEOS) Mission

3.1.4.2.5.1 Mission Objectives

The SEOS mission is intended to investigate remote sensing techniques for measuring transient environmental phenomena from a geosynchronous orbit.

3.1.4.2.5.2 Mission Description

Mission altitude will be 19,323 n mi circular at an inclination of 0^{o}. Nominal orbit positioning will be 96^{o} west longitude and mission duration is to be 2 years. Recovery and/or on-orbit servicing is not planned.

3.1.4.2.5.3 Instruments

Prime instrument for this mission is the Large Earth Survey Telescope (LEST). Other instruments being considered are: Advanced Atmosphere Sounder and Imaging Radiometer (AASIR), Microwave Sounder, Data Collection System and Framing Camera.

3.1.4.2.6 TIROS N Mission

3.1.4.2.6.1 Mission Objectives

The TIROS N vehicle is intended to verify for operational use an advanced environmental operation payload. This spacecraft will have implemented operational versions of remote sensing techniques proven in Nimbus and LRM flight experiments as well as improvements in those sensors carried by the previous N/ITOS vehicles. The TIROS N satellite will be designed so that in orbit refurbishment of the payload can be effected and evaluated.

3.1.4.2.6.2 Mission Description

Nominal altitude of 450 n mi at an inclination of 98.7°.

3.1.4.2.6.3 Instruments

The instruments planned for this mission are: High Resolution Radiometer, Advanced Tiros Operational Vertical Sounder, Scanning Multichannel Microwave Radiometer, Microwave Radiometer/Scatterometer, Cloud Physics Radiometer, Space Environmental Monitor and Data Collection System

3.1.5 SYSTEM DIAGRAMS

See Figure 3-4

3.1.6 INTERFACE DEFINITION

3.1.6.1 SPACECRAFT - PRIMARY GROUND STATION INTERFACE

The Primary Ground Stations shall receive the high data rate X-Band signals transmitted from the EOS Spacecraft. These signals will be at a center frequency in the 8.025 - 8.4 GHz band, and consist of a double-PSK (inphase and quadrature) modulated carrier with a spectrum resembling a conventional QPSK-modulated signal. The signal levels will nominally be as shown in the power budget of Table 3-1. The data modulation will consist of two channels each capable of 120 Mbps. The signal will be transmitted from the Spacecraft with right hand circular polarization. The tracking characteristics of the PGS antenna will be determined by the type of mount employed for the given antenna, since already-emplaced antennas will be employed wherever possible (ETC and ULA). STDN document No. 101.1, Revision 2, May 1974 gives these characteristics.

Table 3-1 EOS - PGS Power Budget

S/C EIRP	30 dBW
FSL	180 dB
O_2/H_2O	1 dB
RAIN	3.1 dB
CLOUD	3.0 dB
TOTAL PROPAGATION LOSSES	187.1 dB
GROUND ANTENNA GAIN	55.4 dB
POINTING LOSS	0.5 dB
SURFACE TOLERANCE	0.3 dB
CKT LOSS	0.5 dB
DUAL FEED LOSS	0.5 dB
NET ANTENNA GAIN	53.6 dB
k	-228.6 dBW/°K/Hz
T	23 dB°K
C/kT	102.1 dB/Hz

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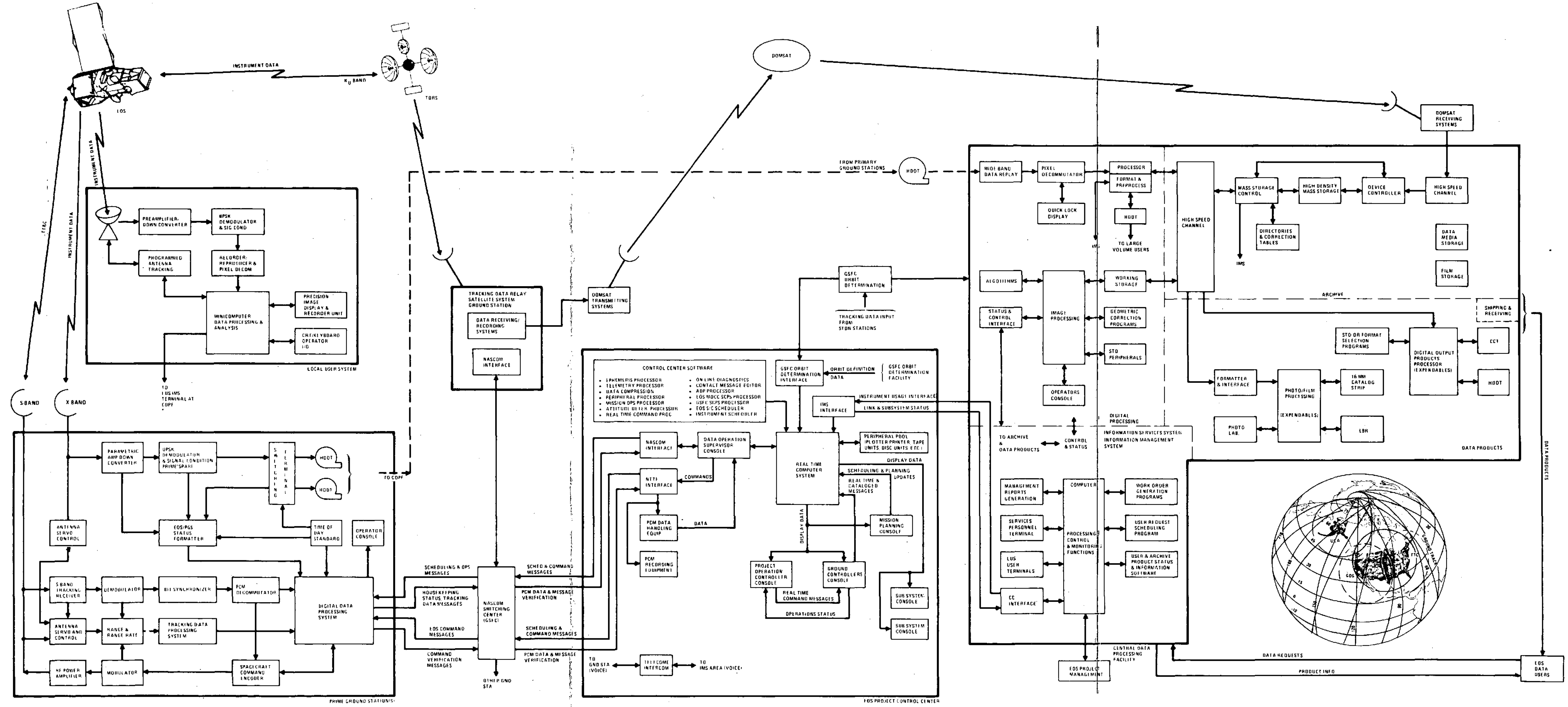

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Fig. 3-4 Earth Observatory Satelite System Functional Intergration Diagram

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FOLDOUT FRAME 2

FOLDOUT FRAME 3

3.1.6.2 PGS OR TDRSS GROUND STATION - CENTRAL PROCESSING SYSTEM INTERFACE

The PGS or TDRSS ground station shall deliver directly from the demodulator, or alternatively, after tape recording, digital binary data streams (NRZ) to the central processing system. These bit streams will consist of the 120 Mbps (including overhead and bit stuffing) TM data and the 16 Mbps MSS data stream derived from the 120 Mbps quadrature channel. These bit streams will be in synchronous format, with an accompanying square wave clock with transitions synchronized to the data (clock rate in Hz equal to the data bit rate). Data and clock interfaces shall be via 72 ohm coaxial cable and connectors.

PGS shall contain magnetic tape recorder units (and playback units if required) that are compatible with playback units contained in the CPS. The data will be transmitted from PGS or TDRSS ground station to CPS by means of direct transmission or physically transported tape reels. The format of the data shall be one of the formats defined in Fig. 3-5.

3.1.6.3 CPS-PCC

There shall be an interface between the ISS and the PCC for purposes of transferring the following types of data:

- Planning data
- System data
- Confirmation of acceptance of order observation requests
- Parameters of acquired data including ephemeris, attitude, and other relevant data.

3.1.6.4 CDPF - USERS

There shall be an interface between the CDPF and the Users. The interface shall be implemented in the Information Services System (ISS) of the CDPF. The interface shall utilize a terminal handling capability and query language to be included in the ISS, although Users shall have the option of interfacing through the intermediary of personnel who shall utilize terminals located at the CDPF. The interface shall permit the Users to order data products, access catalogs, and interact with such other ISS functions as may be necessary or convenient for the operation of the system.

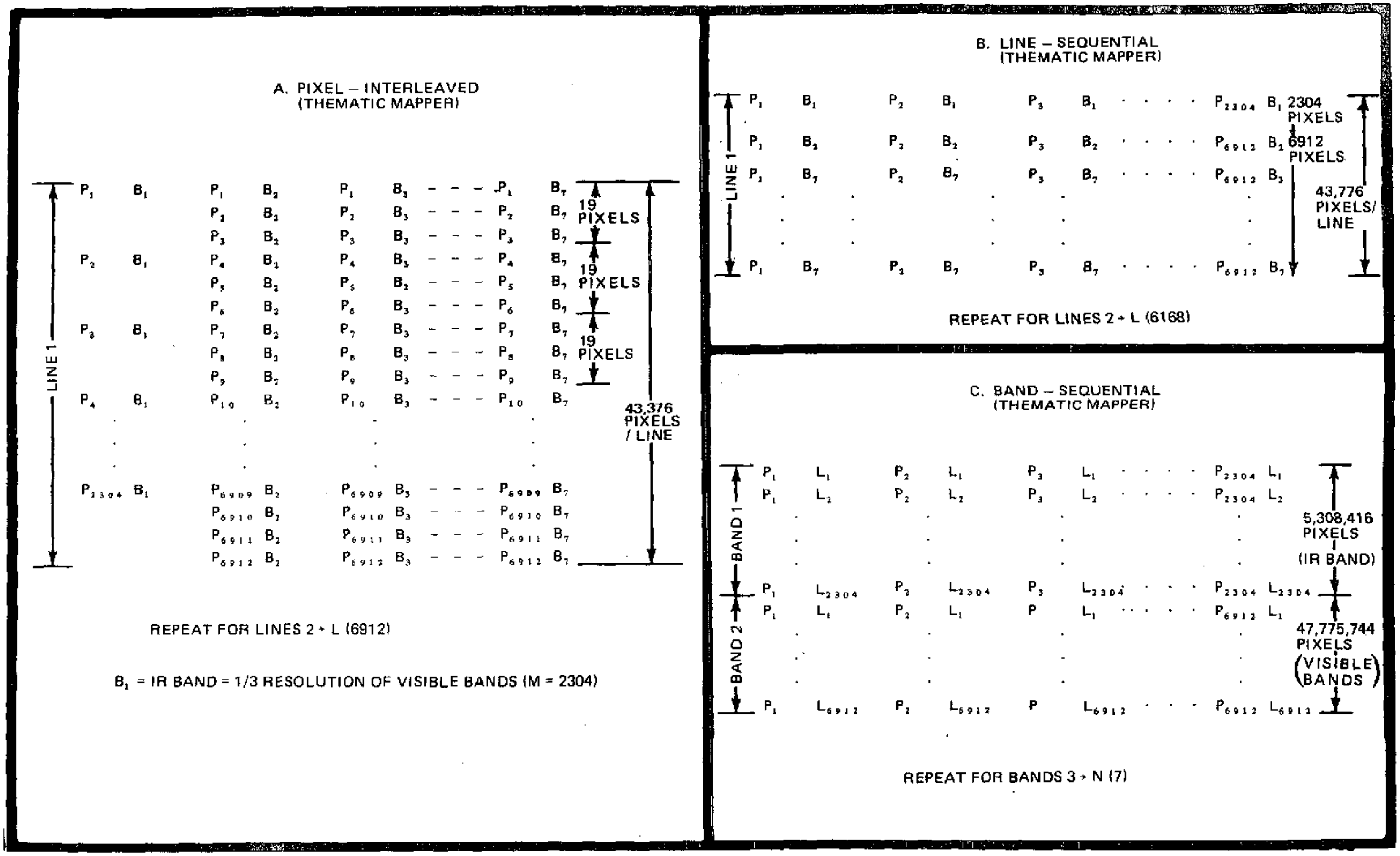


Fig. 3-5 Digital Products Format

The CDPF shall include a capability for shipment of digital data products. It shall support the delivery of photographic products by providing routing and labeling information.

3.1.6.5 CPS - PHOTO LAB

The CPS shall deliver to the photo lab film containing latent images produced in a digital-to-photographic transducer. The photo lab will be responsible for processing of the latent images, for all other photo products derived therefrom and for shipment of all photo products.

3.1.6.6 INITIAL CPS - FINAL CPS

The initial CPS shall, as much as practical, contain such provisions for expansion in the direction of growth to a final CPS as may be required by such aspects of the final CPS concept known at the time of design of the initial CPS. The design of the initial CPS shall as much as practical not preclude expansion in accordance with any final CPS concept as may be under active consideration at the time of design of the initial CPS.

3.1.6.7 SPACECRAFT - LUS INTERFACE

The Local Users Stations will receive the high data rate X-band signals transmitted from the EOS Spacecraft. These signals will be a center frequency in the 8.025 - 8.4 GHz band, and consist of a DPSK modulated carrier. The signals levels will be as shown in the power budget given in Paragraph 3.2.1.4. The data modulation will consist of a nominal 20 Mbps binary data stream, either compressed Thematic Mapper or MSS in origin. It may be directly transmitted data, or it may be data previously tape recorded on the Spacecraft. The signal will be transmitted from the Spacecraft with right hand circular polarization. The fixed-antenna pattern of the spacecraft is such that a user must be within 500 Km of satellite nadir in order to receive adequate signal. The tracking characteristics of the LUS antenna system are defined in Paragraph 3.7.4.1.1.

3.1.6.8 LUS-USERS

The LUS Users shall communicate with the system through one or all, but not to be limited to, of the following equipments:

- Alphanumeric Keyboard/Print Terminals
- Paper Tape Reader/Punch

- CRT Display/Keyboard Terminal
- Stylus Tablet
- Standard Typewriter Terminal
- Other standard Input/Output Devices
- Another computer at remote location.

These devices shall be connected to the system through off-the-shelf interface units when possible. These interfaces shall maintain the system compatibility for all of the above equipments. These interfaces shall not cause any performance degradation of the equipment or system level.

3.1.6.9 DATA FORMATS

The following data formats are defined for use in this specification:

Natural: Detector 1 of band 1, detector 1 of band 2 . . . . detector 1 of band 7, detector 2 of band 1, ... detector 18 of band 7.

Repeat for each pixel in a group of 18 lines. Repeat for each group of 18 lines.

Pixel-Interleaved: Pixel 1 of band 1, Pixel 1 of band 2, . . . Pixel 1 of band N, Pixel 2 of band 1, . . . repeat for each line.

Line-Sequential: Pixel 1 of band 1, Pixel 2 of band 1, . . . Pixel M of band 1, Pixel 1 of band 2, . . . Pixel M of band 2, . . . Pixel M of band N, repeat for each line.

Band-Sequential: Pixel 1 of line 1, Pixel 2 of line 1, . . . Pixel M of line 1, Pixel 1 of line 2, . . . Pixel M of line 2, . . . Pixel M of line L, repeat for each band.

The following nomenclature is used for definition of formats in this section.

B_N - Band number: except for the IR thermal band these are similar and may be arbitrarily assigned - B_1 will be associated with IR band. N = 7 for TM and 4 for HRPI.

L_L - Scan line number: for the TM, L will range from 1 through approximately 6912 and equivalently for the MSS and HRPI.

P_M - Pixel number for each scan line: for the TM, M will range from 1 through 6912 and equivalently for the MSS and HRPI.

3.1.6.9.1 Natural Format (Detector Sequential)

Natural format is defined as above.

3.1.6.9.2 Pixel-interleaved Format

Pixel-interleaved format is defined in Fig. 3-5.

3.1.6.9.3 Line-Sequential Format

Line-sequential format is defined in Fig. 3-5.

3.1.6.9.4 Band Sequential

Band-sequential format is defined in Fig. 3-5.

3.1.6.9.5 LUS Format

LUS formats are defined in Paragraph 3.7.4.3.8.

3.1.6.10 LUS-PCC

An interface shall be provided between all LUSs and the PCC via the ISS to receive S/C-LUS antenna pointing data, receive EOS status information and make known special LUS data requests to the CDPF. With the exception of S/C pointing data, all LUS's shall be capable of operating independent of the CDPF and PCC.

An additional interface shall be provided for use at the option of the LUS Users for physical or electronic transmission of programs and/or data developed or maintained by NASA for the use of LUS users.

3.1.6.11 STDN TRACKING, COMMAND AND TELEMETRY

- TDRSS

The S-band capability of the TDRSS is capable of performing the tracking telemetry and command functions for the Observatory. Interfaces (via the NASCOM network) between the PCC and the TDRS ground station act effectively as a STDN site. Command telemetry data can thus be relayed between the PCC and the Observatory. Tracking of the Observatory can be accomplished from the TDRS ground station and this data will then be routed to the GSFC orbit determination facility for Observatory ephemeris generation.

- STDN

The first link between the EOS Observatory and the PCC is the STDN site supporting the real time operations. There will be a total of three STDN sites used by the EOS. These are:

Goldstone, California	(GDS)
Electronic Test Center	(ETC)
Fairbanks, Alaska	(ULA)

The operational details of these sites are defined in the STDN User's Guide Baseline Document. STDN No. 101.1. May 1974. Revision B.

The second link between the EOS Observatory and the PCC is the NASCOM network. Specific support requirements from NASCOM will be specified in the EOS Mission Operation Plan. These support requirements will be within the capabilities defined in the Data System Development Plan. NASCOM Network. (Revision 9). F7 74-1.

3.1.7 GOVERNMENT FURNISHED EQUIPMENT (GFE)

The following items are GFE:

3.1.7.1 PRIMARY GROUND STATIONS

- Antenna reflectors, mount, tracking and steering system
- S-Band TT&C electronics
- Facilities and power.

3.1.7.2 CDPF AND PCC

- Facilities and power
- ERTS Photographic Laboratory.

3.1.8 OPERATIONAL & ORGANIZATIONAL CONCEPTS

3.1.8.1 OPERATIONAL CONCEPT

The EOS Program is comprised of the Observatory, the Project Control Center, the STDN and TDRS Communication links, the Low Cost Ground Stations, the Central Data Processing Facility, and the Launch Vehicle.

The Observatory will be launched from the WTR and inserted into a circular polar orbit by the launch vehicle. The Observatory will be stabilized and configured for survivability during activation of subsystems. Next, the subsystems and instrument will be checked out and verified operational. The Observatory will maintain earth pointing attitude in a sun synchronous orbit. The instruments will record data and transmit it directly to the ground or via TDRS, or store it for later transmission. After complete system verification, MSS data shall be given full operational status. TM data may be used to enhance or back-up MSS data in addition to providing R&D data. During normal mission operations the Observatory orbit will be adjusted to compensate for orbital decay. The Observatory will be compatible with the Shuttle for possible later retrieval.

3.1.8.2 ORGANIZATIONAL CONCEPT

3.1.8.2.1 Observatory Element

The Observatory Element shall provide a suitable RF environment for the Ground Element to control, integrate, and to receive data from the Observatory.

3.1.8.2.2.1 Control System Element

The Control System Element will track the Observatory and determine ephemeris. It will determine when the Observatory orbit must be adjusted and command the delta velocity required. The Control System Element shall program the area of earth to be scanned by the instruments and command data dumps as required.

3.1.8.2.2.2 Central Data Processing Facility

The CDPF will be implemented over a period of time using the phased approach. The initial facility will be a limited capability system with flexibility to permit changes to be incorporated as NASA and the User community gain experience with the application of digital imaging. The CDPF will be a full capability system; however, the flexibility will be limited for the purpose of obtaining a minimum cost system. It is anticipated that the initial facility will be implemented using principally a configuration of general purpose mini-computers and the full facility will be implemented using principally special-purpose hardware.

3.1.8.2.2.3 Local User Systems/Low Cost Ground Stations

The Users that operate Low Cost Ground Stations will receive data directly from the Observatory and process their own data.

3.2 CHARACTERISTICS

3.2.1 PERFORMANCE

3.2.1.1 PAYLOAD DATA RECEPTION, RECORDING, AND HANDLING

This paragraph treats performance for the overall PGS and the TDRSS. Individual subsystems are specified in Paragraph 3.7.1.1.

Primary Ground Stations using 9-meter antennas shall deliver data at an error rate not greater than 1 in 10^6 when the incident signal ("carrier") power is -157.1 dBW. This power level is defined as the space transmitter EIRP less all propagation losses, but not including polarization or tracking losses. At sites where a 12-meter antenna is employed, the incident signal level for the same performance is -159 dBW. It is anticipated that ETC, Greenbelt will employ a 9-meter; ULA, Alaska, a 12-meter; and Goldstone (GDS) will employ a new 9-meter antenna. Other PGS performance requirements are shown in Table 3-2.

The TDRSS ground station complex will be leased by the Government. Use of TDRSS capability will thus entail an IF interface at the TDRSS location and the entire terminal can be considered GFE to EOS, which supplies only the demodulator and data handling equip-

Table 3-2 Earth Terminal Functional Requirements

TERMINAL CHARACTERISTICS	TERMINAL		
	ETC	ULA	GDS
FREQUENCY RANGE (GHz)	8.025 – 8.4	8.025 – 8.4	8.025 – 8.4
G/T (AT 8.025 GHz) (dB/°K)	31	32.3	31
BANDWIDTH (MHz) (1 dB)			
LOW NOISE AMPLIFIER	375	375	375
OVERALL RECEIVE CHAINS (INCLUDING DOWN-CONVERTERS)	200	200	200
PHASE LINEARITY (RAD/40 MHz)			
OVERALL RECEIVE CHAIN (INCLUDING DOWN--CONVERTERS)	± 0.1	± 0.1	± 0.1
TUNING RANGE (MHz)			
LOW NOISE AMPLIFIER	375 (FIXED)	375 (FIXED)	375 (FIXED)
FREQUENCY CONTROL PARAMETERS			
FREQUENCY STABILITY (TRANSMITTED AND RECEIVER CARRIERS, 3σ)	1 PART IN 10^{11}	1 PART IN 10^{11}	1 PART IN 10^{11}
LONG TERM (MONTH)			
FREQUENCY SETABILITY (TRAMSMITTED AND RECEIVED CARRIERS)	100 kHz INCREMENTS	100 kHz INCREMENTS	100 kHz INCREMENTS
SPECTRAL PURITY	SEE NOTE 1	SEE NOTE 1	SEE NOTE 1
DATA RECORDING			
PEAK DIGITAL DATA RATE	240 MBPS	240 MBPS	240 MBPS
MAXIMUM ALLOWABLE BIT ERROR RATE	10^{-6}	10^{-6}	10^{-6}
MAXIMUM TIME BASE ERROR (% DEVIATION FROM THE NOMINAL VALUE)	0.01	0.01	0.01
RECORDER--TO--RECORDER COMPATIBILITY	YES	YES	YES

NOTE 1: THE TOTAL SPURIOUS CONTENT ADDED TO ANY RECEIVER CARRIER INCLUDING PHASE NOISE AND DISCRETE SPURIOUS SIGNALS, SHALL NOT EXCEED CONDITIONS SPECIFIED AS FOLLOWS:

A. TOTAL SPURIOUS CONTENT FROM BOTH SIDES OF THE CARRIER AT LEAST 25 dB BELOW THE CARRIER FREQUENCY.

B. TOTAL SPURIOUS CONTENT FROM BOTH SIDES OF THE CARRIER AT LEAST 34.5 dB BELOW THE CARRIER LEVEL WHEN MEASURED IN THE FOLLOWING FREQUENCY RANGE:

(RANGE TO BE DETERMINED)

(2)5T-2

ment. The demodulator and data handling equipment for TDRSS shall be the same as defined for the PGS.

Transmission of data from the TDRSS ground station complex shall be performed utilizing domestic communications satellite service. Not more than 4 hours shall elapse between receipt of the data from the Observatory at the TDRSS ground station and delivery to the CDPF.

3.2.1.2 CENTRAL DATA PROCESSING FACILITY

3.2.1.2.1 Input to the Central Processing System

The format of the raw data, as received from the S/C and recorded on the high-density recording medium will be as shown in Fig. 3-6. These data are organized into minor frames each of which contains 342 7-bit words.

One complete west-to-east sweep of the TM consists of 440 minor frames of calibration and synchronization data and 2304 minor frames of active video data. Each minor frame contains three samples from each detector of each high resolution channel. The swath is, therefore, slightly over-scanned with a total width of 2304 x 3 x 27 = 186,624 meters. Approximately 30 pixels margin is left on each end of the sweep (±1151 μ rad) to allow for variations in scan rate.

A scan start frame shall immediately follow receipt of the scanner start indicator and this frame shall contain a digital word that indicates the error between actual scan start (for each sweep) and the ideal scan start time indicated by the S/C clock. This count shall be accurate to 2^{-7} of a pixel (one-third of the minor frame duration).

The elements of the sweep are therefore:

- Active Video Data
  Subminor Frame (one pixel of high resolution channel) - ---------------- 798 bits

  Minor Frame - Three Subminor Frames ---------------- 2,394 bits

  Frame ------ Six minor frames which represents a 486 Km square ---------------- 14,364 bits

  Major Frame - 16 Frames or 96 minor frames

  One Active Sweep - 6912 Pixels (high resolution channels)
  2304 Minor frames
  24 Major Frames
  5,515,776 Bits

- Non-Video (Retrace or Dead-Time Data)

440 Minor frames

1, 053, 360 bits (83.96% scan efficiency)

The minor frames in the non-video interval shall include

Scan start and scan stop frames ----------	2 minor frames
Spacecraft state vector (6:1 redundancy) including time (DOY, sweep no., hour, min, sec) ----------------------------	6 minor frames
Detector calibration sequences (144 total) --	342 minor frames
Sensor status ---------------------------	9 minor frames
Idler and fill data ----------------------	81 minor frames
	440

- Composition of Video Minor Frame

Each minor frame shall contain the following 7-bit words:

One sample from each of the six IR detectors	6 words
Three successive samples from each of the 18 detectors in each of the six visible channels	324 words
S_1, S_2, S_3 Sync words -------------------------	3
S_4, S_5 Minor frame count -------------------------	2
S_6 -------------------------	1
S_7 Scan error -------------------------	1
S_8 Scan rate error -------------------------	1
S_9 -------------------------	1
S_{10}, S_{11}, S_{12}, Sync words -------------------------	3
	342

- Composition of Scan Start and Scan End Frames ------- TBD
- Composition of S/C State Vector Frames ------------- TBD
- Composition of Detector Calibration Frames ---------- TBD

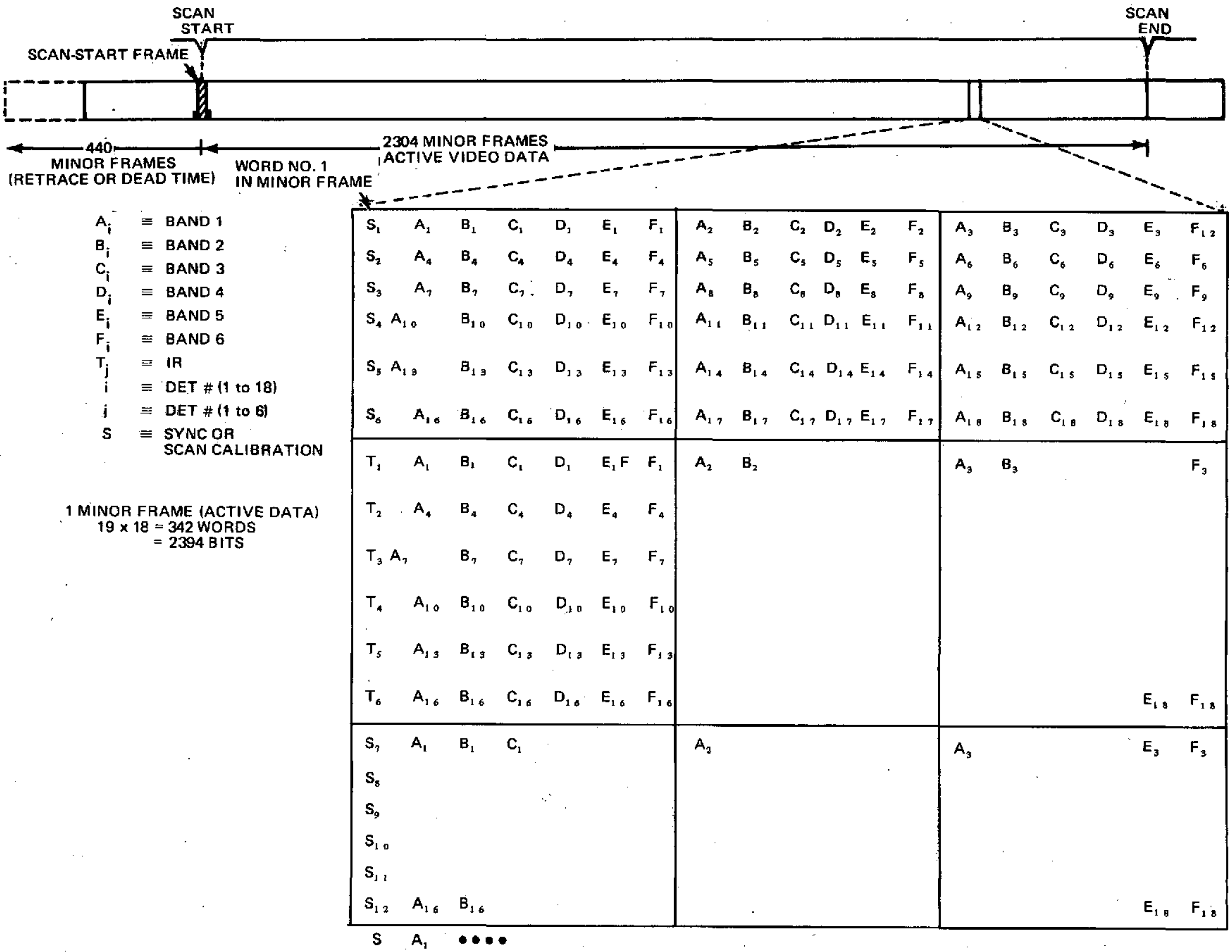


Fig. 3-6 Raw Data Format on High Density Tape

- Composition of Sensor Status Frames --------TBD
- Composition of Idler and Fill Frames --------TBD

3.2.1.2.2 Processing

Three basic levels of processing are identified for the thematic mapper data.

Level	Operations Requirement	Disposition/Options
I	a) Radiometric correction	Resultant images may be displayed or supplied as output products.
	b) One-dimensional line rectification and scan non-linearity correction if necessary.	In b) scan nonlinearity correction may not be required for some instrument options.

Level	Operations Requirement	Disposition/Options
II	a) Computation of resampling grid points to correct for earth curvature, earth rate, orbit, altitude, and UTM grid projection.	• An option is to only perform a) and b) and to provide the necessary information with the information with the original data so that c) can be performed by the User.
	b) Computation of coordinates of desired output points relative to the actual data.	
	c) Compute intensity values for each desired output point using one of three possible interpolation algorithms.	
III	a) Locate ground control points in the images, as required, to refine the resampling grid computation in II a). Generally, the GCP location compensates for (and updates) ephemeris and altitude data.	• Same as option under II, above.
	b) Same as II b).	
	c) Same as II c).	

Note that the requirements for intermediate output products, and the options of performing, or not performing, resampling/interpolation in the Level II and III processing, requires the three levels of processing to be separable and distinct. Note also that Level III processing in effect, replaces Level II processing.

Throughput estimates shall, however, be based on Level I processing and followed by steps a), b), and c) of the Level III processing where bilinear interpolation (see Paragraph 3.2.2.3) is used in III c).

3.2.1.2.3 Output Product Quality

Overall quality of the Thematic Mapper images will be defined in terms of:

- Resolution Accuracy
- Geometric Accuracy
- Radiometric Accuracy

The Central Data Processing Facility (CDPF) shall produce geometrically accurate UTM map projections from the digital image data while retaining, within the accuracies specified below, the basic resolution and radiometric accuracy of the system.

Up to the CDPF the image quality will be defined analytically by the following data:

Resolution Accuracy

- Transfer function of the optics (blur circle)
- Transfer function of IGFOV due to the non-zero detector size
- Combination of the above to give combined blur circle + IGFOV response in terms of a two-dimensional intensity - versus μ radian set of data
- Impulse response of pre-sampling filter which spoils the MTF in the E-W direction (which may include detector electronic bandwidth limitations).

Geometric Accuracy

- Model of scanning including repeatability, nonlinearity and a clear definition of deterministic and random components to these nonlinearities
- Ephermeris accuracy
- Attitude and attitude rate errors

Radiometric Accuracy

- Signal to noise ratio (SNR) for each channel
- Detector noise as a function of intensity level

- Nonlinear A/D conversion law (if applicable)
- Noise bandwidth of presampling filter
- Bit error rate, and error correlation, on the wide band data links.

Given these data, which allow system MTF, noise levels, and geometric fidelity to be defined (or simulated if nonlinearities are involved) up to the point that the digital data enters the CDPF, the following criteria shall apply to the processing/product generation.

3.2.1.2.3.1 For Products to be Supplied in Digital Form (HDDT, CCT)

- The basic resolution accuracy of the system shall be retained, as measured by the overall system MTF, with a degradation of no more than:

  a) ±0.5 dB for frequencies up to one-eighth the sampling frequency $f_s/_8$.
  b) ±2 dB for frequencies $f_s/_8$ up to 0.9 of $f_s/_2$.

- The radiometric accuracy shall be preserved with the SNR of any channel increased no more than 1 dB in the noise level of the spectral channel with the highest SNR. That is, if σ^2 represents the nominal mean square noise level on the channel with the highest SNR, the processing shall increase the noise in any channel by no more than $0.126\,\sigma^2$.

- The fundamental geometric accuracy of the resultant digital products is a function of errors, both internal and external to the system, and the information which is made available for correction of these errors. With the following information available for the processing:

  - Orbit parameters with a precision of 1 part in 10^9, and accuracy (3-dimensions) of 76 meters, one sigma
  - Attitude parameters with a pointing accuracy of 174 μ rad (start of pass) with rate controlled to 162 x 10^{-3} μr/s over 30 seconds, 17.4 μr/x over 30 minutes
  - A local earth model accurate to 30 meters.

  the entire TM image shall be resectioned and resampled, giving a UTM map projection in which individual pixels are located to an absolute accuracy of:

  Case 1 - Orbit data accurate to 76 meters, attitude to 174μr, attitude rate to 162 x 10^{-3} μr/s over 30 sec., 17.4μr/s over 30 min.

  Accuracy ---------------------- 170 m, one sigma

  Case II - Orbit data accurate to 139 meters, attitude to 174 μ r, attitude rate controlled to 162 x 10^{-3} μ r/s over 30 sec, 17.4 x 10^{-3} μr/s over 30 min.

  Accuracy -------------------------- 450 m, one sigma

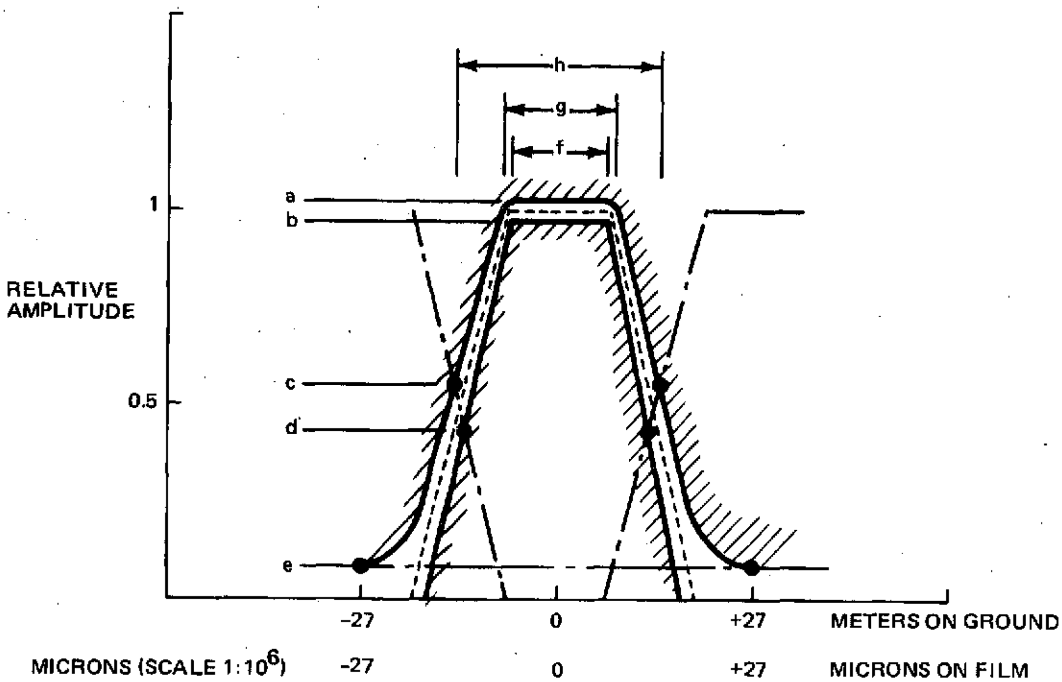
Given that ground control points (GCP's) are found in the images so that emphemeris and attitude errors are reduced, location accuracy shall improve to

Accuracy ---------------------- 15 m, one sigma

3.2.1.2.3.2 For Photo Products

Additional degradation shall be allowed in generating photo products as follows:

- The photo generation process shall have a writing spot with dimensions within the surface of resolution described by the shape specified in Fig. 3-7
- The photo generation process shall preserve radiometric accuracy to within an additional rms error of 1.0% of full scale intensity.



ITEM	NOMINAL	MINIMUM	MAXIMUM
a	1.0	–	$1.0 + 2^{-7}$
b	1.0	$1.0 - 2^{-7}$	–
c	0.5	–	$0.5 + 2^{-7}$
d	0.5	$0.5 - 2^{-7}$	–
e	–	–	2^{-7}
f	13.5 m	13 m	–
g	13.5 m	–	14 m
h	27 m	–	–

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Fig. 3-7 Photo Generation – Spot Size

- The basic geometric accuracy of the digital product shall be preserved except that the following maximum additional errors are allowed:

  a) Line-to-line alignment ---------- 0.1 resolution element, peak.

  b) Linearity within any one line ----- ± 0.03%.

  c) Repeatability from line-to-line --- 0.25 resolution element, peak.

3.2.1.2.4 Throughput and Turnaround

3.2.1.2.4.1 Image Data Processing Load

Image data processing load, when specified in units of bits per day, shall be interpreted to mean image data bits per day, based on a specified picture sample quantization and exclusive of any bits transmitted, handled, stored, processed, or otherwise included together with the image data bits for purposes of error control coding or compatibility with any recording media formats, computer byte or word structure, computer instruction or architectural feature, data identification or header, or other purpose arising out of the transmission, handling, storage, or processing of such image data and not representing information directly originated by the sensor during its scan of the earth.

The ICPS shall be capable of processing an image data processing load of 10^{10} bits per day based on 7 bit quantization of the picture samples.

The FCPS will be capable of processing an image data processing load of 10^{12} bits per day based on 7 bit quantization of the picture samples, for example, TM and/or HRPI data.

3.2.1.2.4.2 Turnaround Time

The CPS shall be capable of processing its specified data load under the scheduling constraints and within the turnaround time specified herein. Under normal conditions all required processed data shall be available for generation of data products within 24 hours of receipt of the raw data from the PGS. All required data products shall be available for distribution to users within 48 hours of receipt of the raw data from the PGS. Under normal conditions the CPS shall perform all required data processing and product generation during a scheduled production operating time of less than 16 hours per day. There shall be a minimum of 8 hours per day available for scheduled preventive maintenance, for avoidance or processing of data backlogs as specified below, for computer program maintenance or development and checkout of program modifications.

In the event of equipment failure requiring the above stated limits to be exceeded, the CPS shall be defined as operating in a backlog mode. In this mode, all required processed data shall be available for generation of data products within 48 hours of receipt of the raw data from the PGS. All required data products shall be available for distribution to users within 72 hours of receipt of the raw data from the PGS.

The cumulative amount of time during which the CPS shall remain in a backlog mode during any 365 day period shall not exceed 96 hours. The maximum throughput degradation under single point failure shall be as discussed in Paragraph 3.5.

3.2.1.2.5 Data Product Quantities

The CPS shall produce data products as defined herein and shall have sufficient capacity to produce these data products in quantities as follows:

3.2.1.2.5.1 High Density Digital Tape (HDDT)

HDDT shall mean the recording medium/format defined in Paragraph 3.7.2.5.2 and shall be produced in a minimum quantity equal to twice the image data processing load specified in Paragraph 3.2.1.2.4 (i.e., two copies each image).

3.2.1.2.5.2 Computer Compatible Tape (CCT)

CCT shall mean a recording medium/format as defined in ANSI-X3.22-1973 entitled "American National Standard, Recorded Magnetic Tape for Information Interchange (800 CPI, NRZI)" or ANSI-X.39-1973 entitled "American National Standard, Recorded Magnetic Tape for Information Interchange (1600 CPI, PL)" or ANSI subcommittee document X3B1-658 entitled "Submission of Proposed Recording Format, Group Coded Recording, 6250 BPI," with additional characteristics as specified in Paragraph 3.7.2.5.1. CCT shall be produced in a minimum quantity equal to 10% of the image data processing load specified in Paragraph 3.2.1.2.4 with User selection of the recording density at the time of product ordering.

3.2.1.2.5.3 Photo Products

The CDP shall produce first generation black and white transparencies in the form of latent images as further defined in Paragraph 3.7.2.5.3 and in a minimum quantity equal to the data processing load specified in Paragraph 3.2.1.2.4 (i.e., one copy each image).

The CDP shall be capable of producing the minimum quantity of photo products by the time the processed data is required to be available for product generation as defined in Paragraph 3.2.1.2.4.

For purposes of turnaround time evaluation, the minimum quantity may be produced during the 8-hour preventive maintenance period of the data processing subsystem.

The CDP shall be capable of producing an additional quantity of first generation black and white transparencies in accordance with the transducer production rate specified in Paragraph 3.7.2.5.3.

Second generation photo products will be produced by a photo laboratory that will also develop the latent images produced by the CDP.

3.2.1.2.6 Archive

The archiving system shall store on-line at least one-day of data collected from EOS. The archiving system shall be modular in design so that an initial system can be expanded and contracted easily without degrading the whole system performance. The archiving system shall have the following characteristics:

- System (archiving) control and fault isolation
- Multiple concurrent I/O data transfers
- Multiple concurrent random searches
- High system reliability
- Error rate of 1 in 1 x 10^{11} or better
- Reuseable archiving media.

The archive storage media shall include:

- On-line for rapid response
- Readily accessible Off-line
- Deep storage for historical records or disaster backup.

The archiving system shall have a local storage for managing its own internal work queues and maintaining an index of on-line and off-line data.

3.2.1.2.7 Information Services System (ISS) Functions

The ISS shall perform the following functions for the CDP:

- Serve as the interface between the CDP and the Users
- Serve as the interface between the CDP and the PCC
- Maintain any required catalogs and/or inventories of image data acquired and data products generated
- Provide a means for User ordering of observations and/or data products
- Provide for scheduling and control of the CDP, quality control of CDP output products, and for interface with CDP personnel
- Maintain any required accounting, reporting, or historical data bases
- Support the routing and delivery of data products by printing mailing labels or by direct transmission (in limited cases.).

3.2.1.3 PROJECT CONTROL CENTER (PCC)

The Project Control Center shall be capable of supporting two EOS spacecrafts in orbit. This support shall be limited to realtime contact with one Spacecraft at any instant of time, but capable of rapid switchover to support the second Spacecraft. Each realtime contact shall be supported for the duration of the contact period (maximum 16 minutes). In addition, the PCC shall be capable of supporting nonrealtime analysis of EOS contacts in form of playback of recorded PCM tapes through the PCC or delayed transmission of PCM data from the remote ground stations.

The PCC shall be capable of performing the following in support of the EOS spacecraft:

- Receive EOS housekeeping telemetry data via the remote ground stations and NASCOM or the NTTF and monitor for quality
- Record the data on analog magnetic tape recorders
- Process the data and format it for display on the console and hard copy units
- Transmit command messages to the EOS spacecraft via the remote ground stations and NASCOM or the NTTF
- Interface with the EOS Central Data Processing Facility and the following GSFC facilities:
  - SCPS
  - Orbit Determination
  - MISCON

3.2.1.4 LOCAL USER SYSTEM CHARACTERISTICS

The RF/IF subsystems of the LUS are complete, independent, receive - only terminals to be used by independent observers to receive an X-Band (e.g., 8.24 GHz), 16 or 20 Mbps differentially encoded phase shift keyed signal sufficiently well to obtain a bit error rate of 10^{-5} or better, as shown in the Power Budget, Table 3-3.

The Data Recording and Decommutation Subsystem accepts the serial data bit stream and associated clock from the Demodulator/Signal Conditioning Subsystem, and records it on an Acquisition High Density Digital Recorder. The Decommutator converts the reproduced data from the recorder into a format suitable for subsequent processing.

The basic LUS RF and data recording subsystem parameters are given in Table 3-4.

The LUS processing subsystem shall include, but not be limited to, a digital computer, random access memory, digital input and output capability, removable disk storage, magnetic tape storage, and other standard peripheral devices. This processing subsystem shall have the capability of performing all of the following processing:

- Radiometric corrections
- Line stretching
- Resampling grid computation
- Co-ordinate computation of the desired data samples
- Nearest neighbor interpolation
- Bilinear interpolation
- Cubic convolution interpolation.

The subsystem shall meet the following throughput performance:

Processing Option	No. of Bands Per Hour	No. of Hours Required Per Band
(1)	1.37	0.73
(1) + (2)	0.58	1.72
(1) + (2) + (3) + (4) + (5)	0.24	4.14
(1) + (2) + (3) + (4) + (6)	0.16	6.32
(1) + (2) + (3) + (4) + (7)	0.07	15.28

Table 3-3 LCGS/LUS Power Budget

S/C EIRP	+ 22 dBW
PROPAGATION LOSSES (INCLUDING RAIN CLOUD, ABSORPTION)	-172 dB
GROUND TERMINAL G/T*	+ 11 dB/°K
POINTING LOSS	- 1.5 dB
k	(-)-228.6 dBW/° K/Hz
C/kT	88.1 dB-Hz
R	73 dB-Hz
E_b/N_o	12 dB
MARGIN	3.1 dB

(2)5T-3

*INCLUDES CIRCUIT AND SURFACE TOLERANCE LOSSES, ETC.

Table 3-4 Basic LUS and Data Recording Subsystem Parameters

RF/IF	LCGS CHARACTERISTICS
FREQUENCY RANGE	8.025 - 8.4 GHZ
G/T (AT 8.25 GHZ)	11 dB/°K
BANDWIDTH (1 dB)	
PREAMPLIFIER	375 MHZ (FIXED)
IF	30 MHZ
TUNING RANGE	375 MHZ
DEMODULATOR	DPSK
E_b/N_o PERFORMANCE	12 dB FOR B.E.R. 10^{-5}
FREQUENCY STABILITY (24 HOURS)	1 PART IN 10^8
FREQUENCY SETTABILITY	10 KHZ INCREMENTS
SPECTRAL PURITY	NOTE 1
DATA RECORDING	
PEAK DIGITAL DATA RATE	20 MBPS
MAXIMUM ALLOWABIE BIT ERROR RATE	10^{-5}
MAXIMUM TIME BASE ERROR (% DEVIATION FROM THE NOMINAL VALUE)	0.01

NOTE 1: SPECTRAL PURITY: THE TOTAL SPURIOUS POWER ADDED TO A RECEIVED CARRIER, INCLUDING PHASE NOISE AND ALL DISCRETE SPURIOUS SIGNALS, SHALL NOT EXCEED THE FOLLOWING LEVELS:

A. 25 DB BELOW THE CARRIER LEVEL MEASURED IN THE BAND TBD.

B. SPURIOUS CONTENT AT OFFSETS FROM THE CARRIER OF 10 HZ OR LESS SHALL BE CONSISTENT WITH THE SHORT TERM FREQUENCY STABILITY REQUIREMENT.

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The system shall be modular such that its configuration can be expanded and contracted.

The processing subsystem shall have the following minimum configuration:

- Central Processing Unit
- Main Memory
- Secondary Storage
  (1) Magnetic Tape Units
- Input/Output
- Peripherals
  - Alphanumeric Keyboard/Printer Terminals
  - Paper Tape Reader/Punch
  - CRT Terminal.

The subsystem shall perform the following tasks:

- Initial data entry
- Format and record arranging
- Radiometrically and geometrically correct the image data
- Respond to User's requests
- Monitoring of other subsystems connected to it
- Analysis of the image data.

3.2.2 PHYSICAL CHARACTERISTICS, GROUND SYSTEM EQUIPMENT (GSE)

The physical characteristics of the GSE shall be such as to provide ready access to interior parts, terminals and wiring, and for adjustments, calibration, complete circuit checking, and removal and replacement of parts. Doors or access plates shall be provided as necessary for access to controls, instruments, servicing provisions, and items requiring frequent maintenance. Fastening devices shall incorporate suitable locking means to prevent their working loose in service.

3.2.2.1 TRANSPORT AND STORAGE

The GSE enclosures for new items shall be designed to facilitate packaging, shipping and storing of the equipment wherever possible. Items that due to weight and size cannot be readily handled by two men during shipment shall have provisions for lifting by material handling equipment.

3.2.2.2 CONTROLS AND DISPLAYS

Controls shall be readily accessible, suitably arranged, and of such size and construction as to permit convenience and ease of operation under all service conditions. The setting, position, or adjustment of the controls shall not be affected by service conditions. Controls shall operate freely, smoothly and without excessive binding, play, or backlash. Knobs and handles shall have high-impact strength and shall be firmly secured to their control shafts. The divisions and lettering on turning dials shall be suitably etched or printed with characters large enough to read under normal lighting conditions. The controls and displays shall be in conformance with MIL-STD-454D, Requirements 28 and 42.

3.2.2.3 MECHANICAL STOPS

Provision for mechanical stops shall be included for adjustable parts. The stops shall be sufficiently rugged to prevent damage to the mechanism.

3.2.2.4 SAFETY

- Interlocking Devices - Interlock devices shall be provided for protecting operating and maintenance personnel from injury by exposed voltages over 70 volts when servicing or adjusting any portion of the equipment.
- Fire Hazards - GSE equipment shall be designed to the extent possible with non-flammable materials with adequate protection devices such as fuses or circuit breakers.

3.2.3 RELIABILITY, AVAILABILITY, AND MAINTAINABILITY

3.2.3.1 CPS

The reliability, availability, and maintainability of the CPS shall be sufficient to meet the throughput and turnaround requirement specified in Paragraph 3.2.1.2.4. The reliability, availability and maintainability shall be demonstrated by operating the system for 180 days and achieving a maximum cumulative backlog mode time of less than 48 hours.

3.2.3.2 PAYLOAD DATA RECEPTION, RECORDING, AND HANDLING

The operational availability, reliability, and maintainability of each element of the payload data reception, recording and handling system shall be such that, out of the total time that the Spacecraft is visible and is transmitting to the ground station at power levels meeting Observatory specifications, and propagation losses do not exceed the design values shown in the Power Budget, over a six month interval, the total percentage of data lost due to equipment malfunction shall not exceed 3% of the total data transmitted.

3.2.3.3 PCC

3.2.3.3.1 PCC Qualitative Requirements

Simplicity shall be used to the maximum practical extent consistent with functional requirements in designing the PCC for reliability. Capability for redundancy checkout shall be provided. Suitable fault detection/isolation shall be provided. Failure of any component shall not propagate or result in failure of other components. Single point failures shall be avoided insofar as possible. In no event shall a single point failure cause an abort of an Observatory contact.

3.2.3.3.2 PCC Quantitative Requirements

Any failure in the PCC shall not cause an Observatory failure to be induced. The PCC shall have a reliability of .999. This is construed as a 99.9% chance of completing a 15 - minute Observatory contact providing the PCC is in the "go" condition just prior to contact.

3.2.3.3.3 Maintainability - Project Control Center

The PCC equipment shall be designed for ease of maintenance. Equipment arrangement shall feature ease of accessibility. Maintainability design objectives shall include:

- Mean-time-to-repair (MTTR) of 15 minutes for any PCC system failure that will prevent meaningful contact with the Observatory.
- Elimination of sequential equipment removals to obtain access to other equipments.

3.2.3.3.4 Availability - Project Control Center

The availability of the PCC shall be .999.

3.2.4 GSE SYSTEM ENVIRONMENT

3.2.4.1 OPERATING ENVIRONMENT

The GSE shall be designed to operate in a normal temperature-humidity controlled computer-type environment. All units requiring forced cooling, such as air conditioning, shall be identified and cooling requirements tabulated in terms of conditioned air (e.g. inlet temperature, cubic feet per minute, humidity content). The GSE shall be capable of operation with a +25°F, -15°F swing from a nominal 72°F ambient. The operating environment for PGS antenna modification shall be consistent with the GFE antennas.

Shipment of GSE equipment to the facility sites shall be in enclosed air-ride vans. Consoles and other electronic equipment shall be shock mounted to shipping pallets for additional protection. The equipment shall be capable of operating within specification limits after exposure to both controlled and natural thermal environments of -40°F to +150°F with a 5°F variation per minute as might occur during truck transportation.

3.3 DESIGN AND CONSTRUCTION

3.3.1 EQUIPMENT

The design and construction of all equipment shall be of standard manufacture in accordance with the best commercial practice or shall conform to the provisions of all applicable specifications regarding parts, materials, processes, electromagnetic radiation, nameplates, product marking, workmanship, interchangeability, safety, and human engineering, and particularly as described in the following sections.

3.3.1.1 CORROSION RESISTANCE

Metals shall be either of a corrosion resistant type or suitably treated to resist corrosion. Protective methods and materials for cleaning, surface treatment, and application of finishes and protective coatings shall utilize MIL-F-7179. Cadmium, zinc, or electrodeposited tin are permissible.

3.3.1.2 FUNGUS RESISTANCE

Materials which are not nutrients for fungi shall be used to the greatest extent practicable. Where nutrient materials must be used outside of hermetically sealed containers such materials shall be treated with a fungicidal agent utilizing MIL-STD-454.

3.3.1.3 ELECTRONIC EQUIPMENT

New electronic equipment shall be designed and manufactured using MIL-S-8512, MIL-E-4158, and MIL-T-21200 as guides. Components shall be selected from MIL-approved lists to the greatest extent practicable. Proven off-the-shelf equipment may be utilized in an unmodified state provided functional and service conditions can be satisfied.

3.3.1.4 BONDING AND GROUNDING

GSFC specification S-533-P-11A "Grounding System Requirements for STADAN Stations", Paragraphs 3.2.1.6 (Equipment Rack Ground Bus), 3.2.1.7 (Equipment Rack

Jumper), 3.2.1.8 (Equipment Power Isolation) shall be used for grounding and bonding criteria.

3.3.1.5 SOLDERING

Soldering shall be in accordance with NASA specification NBH 5300.4 (3A) "Requirements for Soldered Electrical Connections". Only the following paragraphs apply:

3A300 - Facility Cleanliness

3A301 - Environmental Conditions

3A302 - Lighting Requirements

3A303 - Tool & Equipment Control

3A304 - Heat Sources

3A305 - Conductor Preparation Tools

3A306 - Thermal shunts

3A308 - Materials Selection

3A309 - Solder

3A310 - Flux

3A311 - Solvents

3.3.1.6 ELECTROMAGNETIC RADIATION

EMC design efforts shall consider the following:

- Interface compatibility between the various elements of the system shall be insured at each stage of analysis, design, and construction
- Equipment shall be designed and selected using MIL-STD-461 as a guide
- An EMC interface safety margin of 6dB minimum for power and signal circuits shall be employed.

3.3.1.7 NAMEPLATES AND PRODUCT MARKINGS

Identification and marking of the system components shall conform with the requirements of MIL-STD-130 or applicable Grumman STD Specs., i.e., GSS 4710-1 and/or GSS 4711.

3.3.1.8 WORKMANSHIP

All GSE hardware including detailed parts, subassemblies and installations shall be fabricated and assembled and finished to good commercial practice or in a manner which satisfies the workmanship standards specified in the current Government approved Grumman drawing No. 659001.

3.3.1.9 SAFETY

The GSE shall be designed to insure the safety of operating and maintenance personnel. Shock hazards shall be guarded against in all electronic and electrical equipments. The design criteria indicated in Paragraphs 3.2.2.4 and 3.3.1.4 shall be followed.

3.3.1.10 HUMAN ENGINEERING

Equipment shall be designed using the requirements of Paragraphs 5.1 through 5.7 of MIL-STD-1472 as design guides.

3.3.2 COMPUTER PROGRAMMING

The following paragraphs describe minimum requirements for programming standards which shall be followed throughout the development, implementation, and design verification of computer programs.

3.3.2.1 COMMUNICATION AND CONTROL

Programs shall be designed to be independent of one another with any communication and control handled via the executive program and associated tables. Standardization of communication and control between computer program components shall be accomplished. This provision may be relaxed for programs or program segments having a substantial impact on processing speed or storage.

3.3.2.2 SYMBOL CONVENTION.

A symbol is a particular set of alpha-numeric characters. A symbol convention is a set of rules governing the selection of symbols used for identifying components of a program and locations within the individual programs. For each computer program CI, conventions shall be developed that shall force symbols to be chosen on the basis of their utility rather than arbitrarily. Exceptions to the established system of notation shall be appropriately specified.

3.3.2.3 PROGRAM LANGUAGES

Where common higher order languages are used in programs, the languages shall conform to appropriate ANSI standards such as those specified in Paragraph 2. Any exceptions to the ANSI standards shall be permitted only for the purposes of increased processing speed or reduced storage and shall be fully explained and justified in the program documentation.

Where languages are developed for the specific purpose of this system, the languages shall be fully specified and documented.

The use of assembly language for computer programs not provided and maintained by the hardware manufacturer shall be minimized except for:

- That portion of a program having a substantial impact on processing speed or storage, or
- The use of special classes of programmable processors for which common higher order languages do not exist.

3.3.2.4 PROGRAM CODING

Program coding shall be accomplished in a straightforward manner to facilitate program maintenance. This provision may be relaxed for programs or program segments having a substantial impact on processing speed or storage.

3.3.2.5 FLOW CHART SYMBOLOGY

Standardization of flow chart symbology shall be accomplished in accordance with American Standard X3.5 dated 1970.

3.3.2.6 COMMENTS OF PROGRAM LISTINGS

All program listings shall be thoroughly annotated to facilitate understanding of the program design logic. This annotation shall include, but not be limited to a heading comment identifying the task or tasks being performed in a subprogram.

3.3.2.7 PROGRAM ORGANIZATION

The computer program CI's shall be designed to be amenable to change. The program organization and segmentation shall be designed so that:

- Modifications may be made to individual program components with minimum effect on other components

- The impact of changes or additions to the data base or non-central hardware is localized
- The degradation encountered upon disabling one or more program components for modification or maintenance is minimized.

3.4 DOCUMENTATION

Appropriate documentation shall be provided to a sufficient degree of detail and level of definition:

- To permit proper operation, preventive and diagnostic maintenance to be performed so as to provide the system throughput, turnaround, and data reception performance of the GSE specified in Paragraphs 3.2.1.2.4 and 3.2.3.2
- To permit the initial system to be expanded and extended by NASA in accordance with the growth concept discussed in Paragraph 3.1.8
- To permit proper operation of the Observatory.

3.4.1 DOCUMENTS FOR MAINTENANCE, OPERATION, AND FUTURE EXPANSION

The contractor shall provide documentation for all new hardware and for all modified hardware. This documentation shall include the rationale, in narrative form, behind the logic design of new equipment and design modifications. This narrative shall include the logic flow or signal flow referring to the logic diagrams and/or schematics. The documentation to be provided shall be in accordance with the following paragraphs of Goddard Specification STD-256-4 dated July 1966 entitled "Preparation of Operation and Maintenance Manuals".

1.3.1	Type I Manuals
1.5	Writing Requirements
3.3.3.2	Cable Requirements
3.4	Operation
3.7	Drawings

3.4.2 DOCUMENTS FOR FLIGHT OPERATION (REFERENCE)

Documentation will consist primarily of a System Design Manual and various Functional Operations manuals. Additional documentation will be the Orbital Requirements Document and the Telemetry Calibration Handbook.

These documents must be developed early in the program to provide detailed information to all EOS personnel. The System Design Manual will be generated by design and operations personnel to provide a single source for the hardware characteristics of each vehicle.

The Functional Operations Manual for each subsystem will be generated by operations personnel. Each manual must define a specific subsystem along with associated commands, telemetry, and ground system data displays.

The ORD will contain the orbital requirements necessary to support in-flight operations. The ORD will also contain a detailed Mission Plan and an orbital time-line showing the planned events of the mission on a contact-by-contact basis. It will also contain contingency plans, Mission Rules, data display assignments, and detail plans for Shuttle resupply and retrieval.

The Telemetry Calibration Handbook (TCH) will contain all bilevel and analog data points and will further contain all the curves and coefficients associated with each analog telemetry point. This document will be updated as required from reports of test results, analytical studies and if necessary flight data.

3.4.3 DOCUMENTS FOR FLIGHT OPERATIONS (OPERATIONAL)

During the operational life of the EOS the following reports shall be prepared:

- Contact Summary Report - The report will be a form-type report for each contact. It will include power supply status, attitude information, control mode, commands executed, and anomalies. This report is filed as a permanent record within the control center.

- Daily Report - This report summarizes each 24-hour period. It shall include the status of each test, station contacts, significant events, total viewing time, satellite and ground system problems, and plans for the next 24 hours. This report will be distributed daily.

- Weekly Report - This report shall be issued for the EOS since it provides a statistical summary of the mission for each week and from the time of launch.

- Monthly Report - This report shall summarize the following for each period:

  - Subsystem Status
  - Ground System Status
  - Reporting Memoranda

- Anomaly Report - This report shall be a form sheet and shall be filled out by the Controller on duty at the time an unusual condition occurs. The initiator may recommend further testing, data analysis, or no action at all. A summary of these reports briefly defining the anomaly and action performed or required will be kept and distributed on request. The summary shall be included in the 30-day report.

Memos shall be prepared for each anomaly or malfunction that occurs. The memo shall include a description and time of occurrence, data substantiating the problem, any analysis, conclusions, and/or recommendations. A list of memos published for any one period shall be attached.

- Malfunction Report - Malfunction reports usually result from an anomaly report when it has been determined that an actual failure has occurred. This shall be a formal sheet completed by mission operations personnel for distribution by Project personnel. It includes all significant information on the equipment failure and references any memos pertaining to the failure. Corrective action and project concurrence is noted.

- Ground System Failure Report - This report shall be filled out by the ground Controller on duty at the time the problem occurs. This report describes the problem, time of occurrence, and any recommended action. The report transmits information between shifts.

- Routine Operations Logs - There will be no distribution of logs; they shall be filed and remain within the EOS operations area. They shall be readily available to all interested parties.

- Contact Log - A log shall be kept in cloth-bound books and consist of all pertinent events that occur during a contact. The Controller documents this information during a contact and initials his entry. The information entered includes orbit number and station, commands and command groups executed, anomalies, and housekeeping events. Events planned but not completed are also noted.

- Miscellaneous Logs - Logs shall be maintained where a record of long-term degradation data is observed. An example is gyro-drift degradation.

- 30-Day Report - The Contractor shall supply a 30-day post launch evaluation report. This report will cover the time period from pre-launch through the first thirty days of operations. The prime areas of evaluation will be mission and subsystem performance. A report shall then be filed each year for the remainder of the mission.

- Post Mission Evaluation Report - The Contractor shall submit a final mission report. This report shall be similar in content to the 30-day Report with the additional analysis of problems and events leading to end-of-life. As in the 30-day report, it shall be divided into mission and system performance.

- Mission Performance - This section of the final report shall contain a timeline history of events and problems that occurred throughout the life of the satellite. It will not include the level of detail, such as commands executed that were in the 30-day report. The timeline shall include all malfunctions and significant events with descriptions and conclusions. End-of-life problems and methods of operation shall be described.

- System Performance - This section of the final report shall be very similar to its counterpart in the 30-day report. Detailed analysis shall concentrate on significant problems and malfunctions that occurred throughout the life of the observatory.

3.5 LOGISTICS

3.5.1 CPS

The design of the maintenance and supply system shall be sufficient to guarantee that the system throughput and turnaround requirement of Paragraph 3.2.1.2.4 will be satisfied. The time for complete malfunction correction is defined as the clock time beginning from detection of the malfunction and including dispatch and travel of any required repair personnel, diagnosis, shipment and receipt of any required parts, repair, system restart, and correction of any data incorrectly processed as a result of the malfunction.

No single point failure that could require more than 16 hours for complete malfunction correction shall reduce the system throughput to less than 2/3 of the required average rate.

3.5.2 MAINTENANCE - PCC

The PCC shall be maintained by performance of preventive maintenance that does not interfere or interrupt system readiness status. Corrective maintenance shall be accomplished as needs are identified. On-line diagnostic and trouble-shooting activity shall be an integral part of the PCC design. This activity shall in no way interfere with the PCC prime function of observatory contact, command and control, status analysis, and planning. Safeguards shall be included to prevent a malfunctioning section of the PCC, being serviced, from adversely affecting the PCC prime function.

Corrective maintenance shall be performed in-place on a replacement basis insofar as practical. This shall be performed by PCC personnel. Equipment that cannot be repaired at the PCC, or other GSFC labs, shall be returned to the vendor for repair or refurbishment.

3.5.3 FACILITIES AND EQUIPMENT - PCC AND CDPF

The PCC and CDPF shall be located at GSFC. The exact location within GSFC shall be specified at a later date by GSFC. All environmental and power requirements shall be furnished by GSFC. The Contractor shall specify these requirements. Facility power shall consist of normal 60 Hz GSFC base power. The GSFC calibration laboratory shall be available for recalibration of PCC and CDPF electrical equipment on an as-needed basis.

3.5.4 DATA RECEPTION, RECORDING, AND HANDLING

The logistics system of the existing or planned PGS and/or TDRSS systems shall be used.

3.5.5 SUPPLY

An adequate supply of back-up hardware for the GSE is required. The Contractor shall recommend, in conjunction with GSFC personnel, spares suitable for the design life of the GSE.

3.6 PERSONNEL AND TRAINING

3.6.1 PRIMARY GROUND STATION

The EOS mission requirements for housekeeping data acquisition and Spacecraft command and control do not require modification of the STDN ground stations or changes in standard operating procedures. Therefore, no additional personnel or specialized training is required.

3.6.2 PROJECT CONTROL CENTER

The PCC staffing structure takes on two distinct forms - one for the prelaunch phase, and one for post launch. These are defined in the following paragraph.

3.6.2.1 PRELAUNCH PCC STAFF STRUCTURE

The prelaunch phase for the PCC area is concerned with getting ready to fly the Observatory, and the effort is broken down into four areas as follows:

(1) PCC Design and Development - This activity is concerned with defining the PCC hardware configuration, negotiating hardware interfaces, performing detail design, and actual development and proof testing of the PCC. PCC hardware documentation is included.

(2) Software Design and Development - This activity is concerned with defining and developing all of the software which will run within the PCC including documentation, test plans, and proof testing. A mission simulation effort is also included, although part of this, if not all, will run external to the PCC.

(3) Mission Planning - This activity is concerned with defining the exact procedures and facilities (within the bounds of 1 and 2 above) to be used in the performance of the observatory mission. The major activities are:

- Mission Plan Development - launch, survival, initial, and on-going operations

- Command and Telemetry Management - receiving and steering the Observatory command and telemetry complement to assure that the required operational commands and information is available.

- PCC Display Design - CRT's, printouts, strip charts, status lights, meters, etc

- Command Pool Definition

- Status Data Limit Definition

- SCPS Specifications

- Formulation of mission constraints and rules

(4) Mission Preparation - This activity is concerned with ensuring that the three areas described above are coordinated into a smoothly functioning system by the time of launch. A simulations effort is central to this activity.

3.6.2.2 POST-LAUNCH PCC STAFF STRUCTURE

The PCC organization for the on-going flight operations is broken down into three areas:

(1) Mission Operations - This group is concerned with the real time support of the Observatory, and with the detailed operational analyses and planning following launch.

(2) Ground Station - This group is concerned with the operation and maintenance of the PCC hardware.

(3) Mission Support - This group is concerned primarily with the effective planning of the Observatory operations. Interfacing with the CPF-IMS is of central importance in this area. This area also interfaces with NASA/GSFC MISCON, orbit determination and SCPS group.

Figure 3-8 defines the organizational structure for the post-launch PCC effort.

3.6.2.3 PCC STAFF TRAINING

The primary objective of training simulations will be to provide prelaunch operational experience for mission operations personnel. The simulation must allow the operations teams to be exposed to the various functions that they will be performing post-launch. The secondary objective of the simulation must be to check out the proper functioning of the ground software/hardware complex and the flight AOP.

The simulation shall use a general purpose high speed digital computer with a software system that will closely imitate the functions and responses of the real Spacecraft.

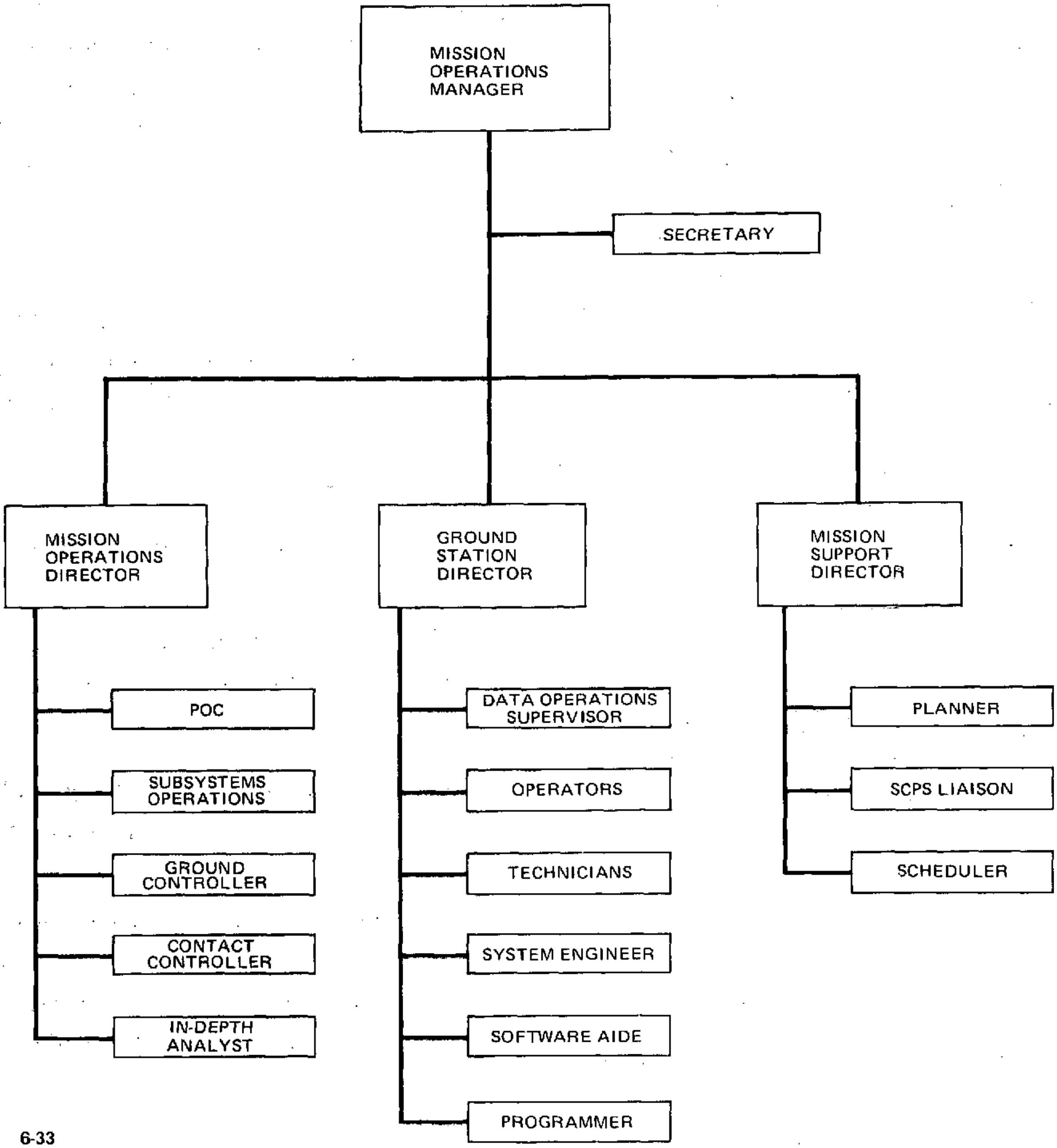

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Fig. 3-8 Post - Launch PCC Organization

Since the Observatory subsystems will be modular, the simulation software package shall be developed along the same lines. Any variation in each Spacecraft shall be duplicatable with a minimum impact on the whole software package. This flexibility shall also extend to help evaluate any post-launch anomalies that may occur.

A comprehensive training program based on certain critical portions of the vehicle checkout phase of the Mission Plan shall be developed so that the operations teams can gain the proficiency needed for smooth post-launch operation. After each segment has been used normally, the insertion of faults and failures shall be used to further train the teams under non-nominal situations. Simulation efforts shall also include the interfaces with the Shuttle for resupply and retrieval.

3.6.3 CENTRAL DATA PROCESSING FACILITY

The following CDPF staffing plan is applicable only after the basic software and hardware systems have been delivered and are operational. Two functional areas shall be staffed. These are the operational and the facility support areas. The functional organizational structure is shown in Fig. 3-9.

3.6.3.1 PRODUCTION OPERATIONS

All CDPF personnel shall be directed by the Operations Manager. He shall supervise the Facility Production Manager who shall direct three shifts of CDPF operators.

Production facilities shall be operated 7 days per week, 16 hours per day, and thus shall require three operational shifts to maintain a 24-48 hour turnaround for User products.

3.6.3.2 SUPPORT OPERATIONS

CDPF production planning, software maintenance, and hardware maintenance shall be performed on a one shift, 40-hour per week basis. A Facility Support Manager shall supervise the support personnel.

Because 16 hours per day are dedicated to CDPF product production, the support personnel shall be required to perform their regular shift work during the 8 hours per day that production is not in progress. Further, a hardware maintenance technician is required to be on call 24 hours per day to obviate production problems that could occur during the 16 hours operation time per day.

3.6.3.3 TRAINING REQUIREMENTS

All operational and support personnel shall undergo classroom training in the following areas:

- System Orientation and Operation - 40 hours - All personnel
- Production Equipment Operation - 120 hours - Operation Personnel
- Equipment and Software Maintenance - 240 hours - Support Personnel.

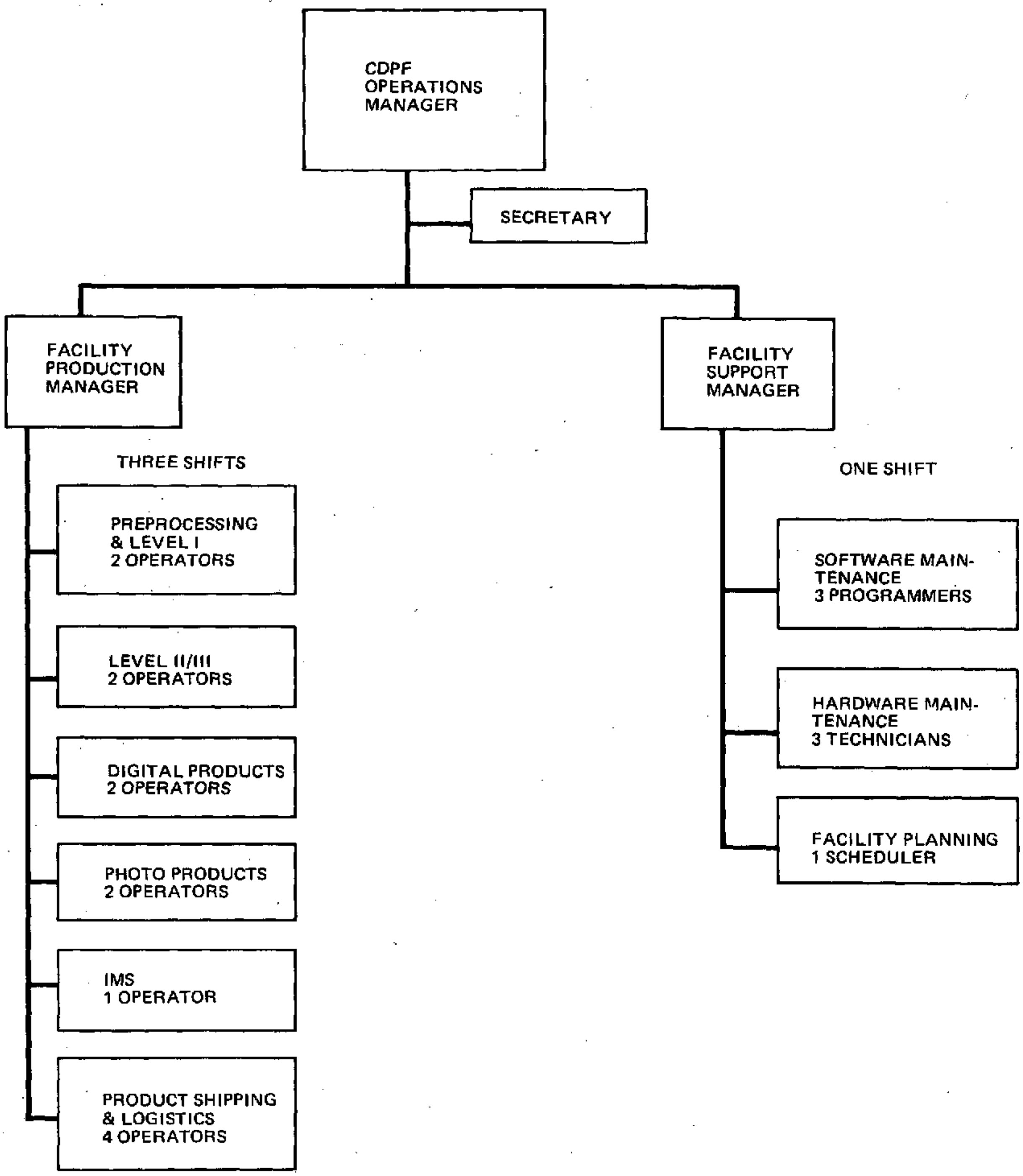

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Fig. 3-9 CDPF Organization

In addition, all personnel shall undergo on-the-job-training (OJT) for a period of six weeks before the facility personnel shall be considered fully qualified to operate the CDPF.

The system contractor is required to provide class material and instructors to train the CDPF operational personnel. All classroom and OJT activities shall be provided and begin within one month after the CDPF is delivered.

3.7 FUNCTIONAL AREA CHARACTERISTICS

3.7.1 DATA RECEPTION, RECORDING, AND HANDLING SYSTEM

3.7.1.1 PRIMARY GROUND STATION - RF/IF SUBSYSTEMS

Figure 3-10 shows a diagram of the PCS-RF/IF Subsystem

3.7.1.1.1 Antenna and Feed

EOS direct-link reception and recording equipment shall be installed at three STDN terminal locations: Goldstone, California (GDS); Fairbanks, Alaska (ULA); and Greenbelt, Maryland (ETC). The majority of RF/IF and baseband equipment will be the same at all three locations.

The following antenna modification shall be made:

- One of the 9 meter antennas at ETC shall be modified with a dual S- and X- band feed assembly.
- A new 9 meter antenna, furnished from Government inventory, shall be installed at GDS and modified with a dual S- and X- band feed assembly.
- The 12 Meter antenna at ULA shall be modified with an additional X- band receive-only feed.

The basic antenna performance parameters are listed in Table 3-5.

3.7.1.1.2 Low Noise Preamplifier

The low noise preamplifier shall be mounted directly behind the antenna feed* in order to achieve the lowest possible noise figure. The preamplifier shall have a performance adequate to enable the overall X-Band receiving system to achieve an overall system effective noise temperature of 200^{O}K. This assumes an antenna noise temperature contribution of 65^{O}K. Other preamplifier parameters are shown in Table 3-6.

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*It is acceptable to mount a portion at the feed, and further stages of amplification elsewhere, providing overall noise temperature specifications are met.

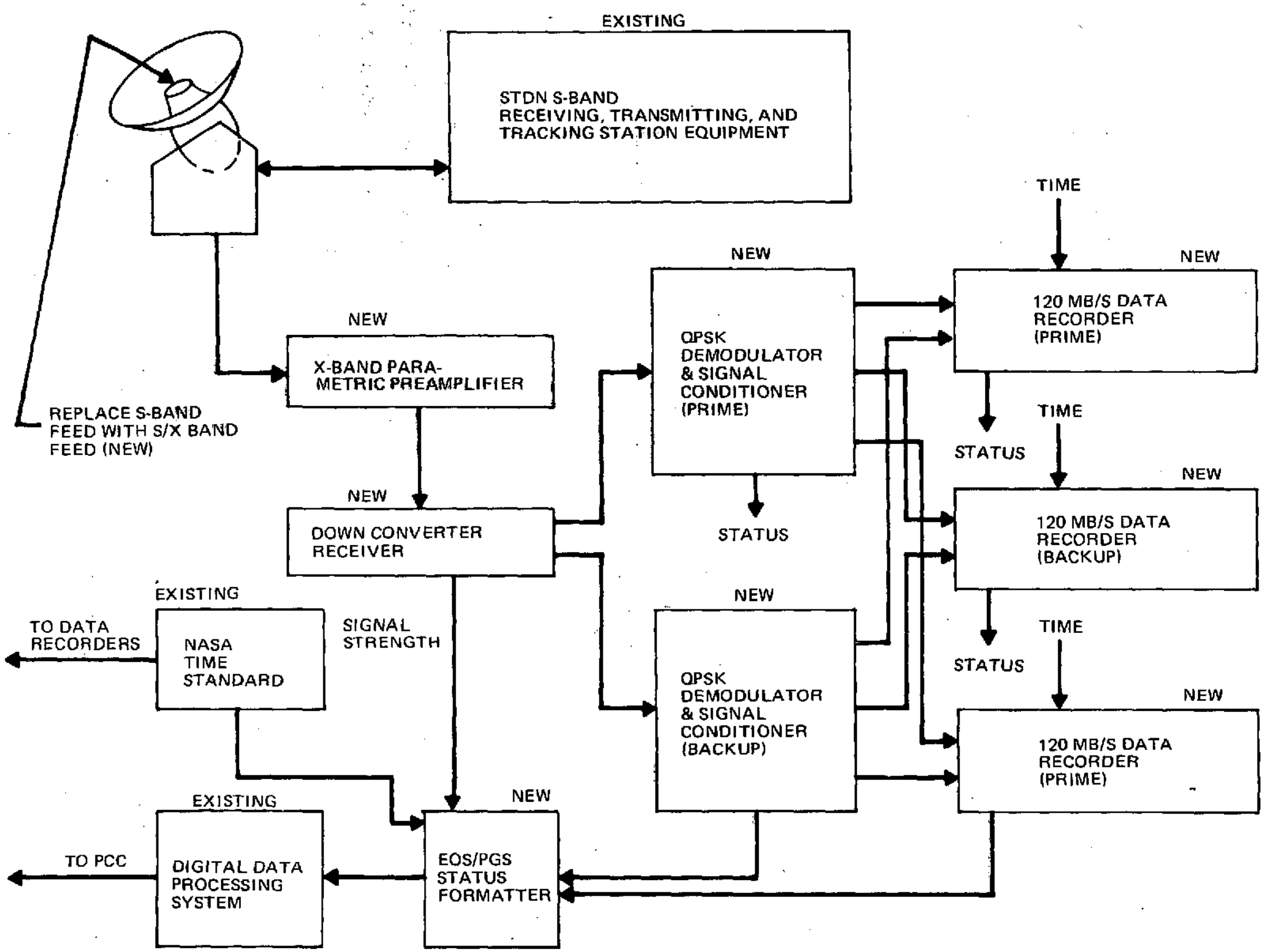

Fig. 3-10 Data Reception Diagram (PGS)

Table 3-5 Dual-Band Antenna and Feed Performance Parameters* (9 Meter Antenna)

DIAMETER	9 METERS (30 FT.)
FREQUENCY BANDS	S-BAND 2200-2300 MHz (RECEIVE) 2090-2120 MHz (TRANSMIT)
	X-BAND 8.025-8.4 GHz (RECEIVE ONLY)
	OTHER BANDS (IF ANY) RETAINED AS PRIOR TO MODIFICATION
GAIN (NET)	AT 8.025 GHz, 54.1 dB
	S-BAND 1/2 dB DEGRADATION RELATIVE TO ANTENNA PRIOR TO MODIFICATION
AXIAL RATIO	1 dB
POLARIZATION	RIGHT-HAND CIRCULAR
*BASIC MECHANICAL AND TRACKING PARAMETERS OF THE USB/STDN SYSTEM AT S-BAND ARE RETAINED.	

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Table 3-6 Low Noise Preamplifier Parameters

NOISE TEMPERATURE	SEE TEXT – APPROXIMATELY 125°K
FREQUENCY BAND, TUNING, AND BANDWIDTH	8.025-8.4 GHz (-1 dB BANDWIDTH, FIXED TUNED)
GAIN	NOMINAL 30 dB (SUBJECT TO DOWN-CONVERTER DESIGN AND LOCATION)
INPUT LEVEL FOR 1 dB COMPRESSION	-60 dBm TO THRESHOLD
GAIN RIPPLE	±0.5 dB
GAIN SLOPE	±0.3 dB/10 MHz
INPUT VSWR	1.5:1 MAXIMUM

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3.7.1.1.3 Downconverter and Receiver

This subsystem shall be built as an integral X-Band input, 700 MHz IF output receiver, or it shall be configured as a downconverter installed at the antenna along with the preamplifier, with the "receiver" installed in a rack indoors. The overall performance characteristics for the downconverter/receiver are shown in Table 3-7.

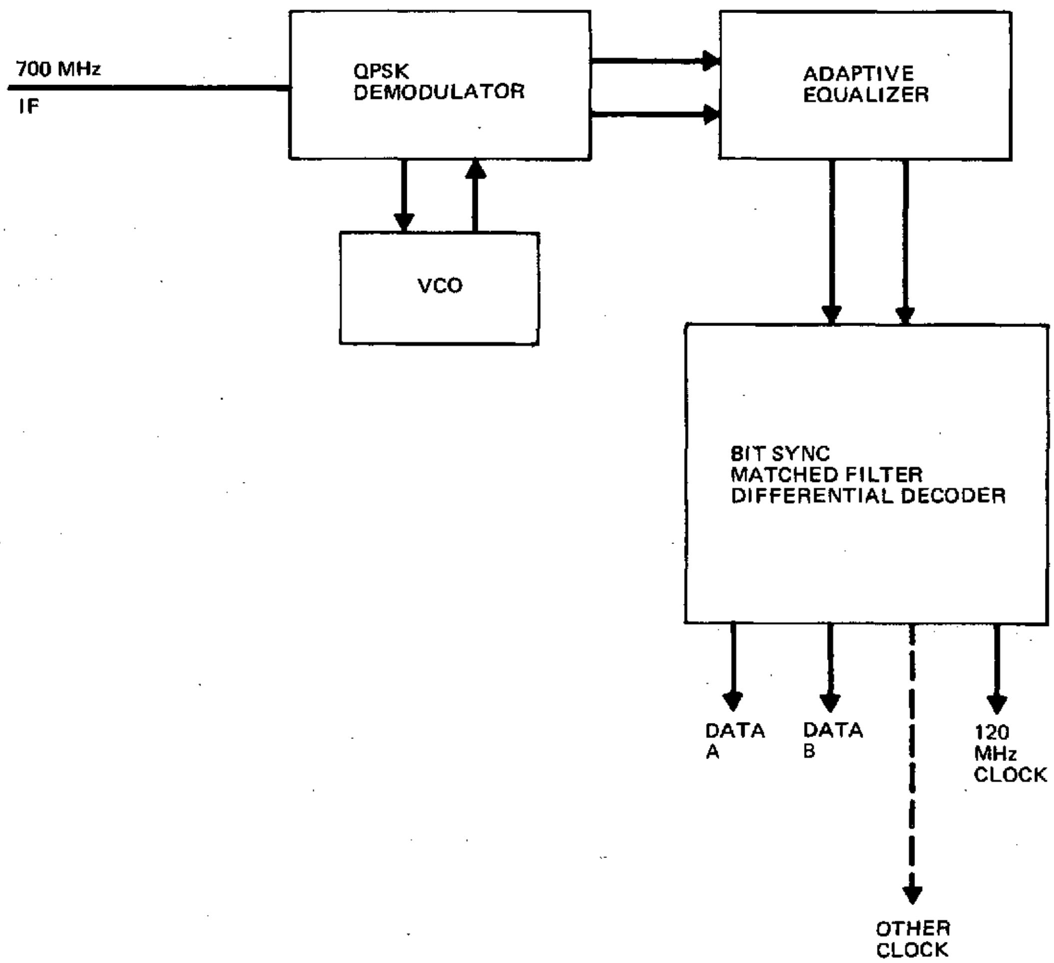
Table 3-7 Downconverter/Receiver Characteristics

INPUT FREQUENCY BAND	8.025-8.4 GHz
NOISE FIGURE	10 dB
CENTER FREQUENCY TUNABILITY	100 KHz INCREMENTS OVER BAND
I. F. BANDWIDTH (1 dB)	200 MHz*
OUTPUT FREQUENCY (TO DEMODULATOR)	700 MHz
OUTPUT	50 Ω COAXIAL
OUTPUT NOMINAL LEVEL	-30 dBM
*SMALLER BANDWIDTHS MAY BE SELECTABLE	

(2)5T-7

3.7.1.1.4 Demodulator and Signal Conditioning System

The digital demodulator subsystem shall accept the 700 MHz signals from the receiver and demodulate quaternary phase shift keyed (QPSK) signaling at an overall data rate of 240 Mbps. This data will be output as two synchronized 120 Mbps channels, transmitted as two quadrature PSK signals. See Fig. 3-11. Alternatively, the demodulator shall operate with an offset-QPSK signal, and separate from the demodulated 240 Mbps data stream the two 120 Mbps channels. In addition to the aforementioned mode, a dual rate mode is required whereby one of the data channels is 120 Mbps, while the other consists of bit-replicated or bit-stuffed data of 16 Mbps rate, transmitted over the QPSK channel at a 120 Mbps signaling rate. In this mode the demodulator and signal conditioning system will extract the 16 Mbps data. Differential encoding/decoding shall be employed at baseband to resolve ambiguity.



(2)5-9 **Fig. 3-11 240 Mbps QPSK Demodulator and Signal Conditioning Subsystem**

The subsystem shall include: an adaptive equalizer; a bit synchronizer utilizing a matched filter approach; ambiguity resolution, and data reformatting or destuffing as required by the data formatting used in the Observatory Data Handling subsystem for transmitting the MSS data via a 120 Mbps channel.

The average output bit error probability for the demodulation system shall be within 2 dB of the theoretical E_b/N_o over the range of probability of bit error, P_e, of 5×10^{-7} to 1×10^{-2}. The total phase noise of ground terminals and satellite transmitter, as given in Paragraph 3.2.1.1 and the Observatory Segment Specification, respectively, shall not degrade the performance specified by more than an additional 0.1 dB.

The demodulator shall acquire carrier and bit timing synchronization within 10 seconds at ± 100 KHz frequency uncertainty, over the range $5 \times 10^{-7} \leq P_e \leq 1 \times 10^{-2}$. While in this mode the demodulator shall be capable of tracking a frequency with a maximum drift rate of 2 Hz.

The availability requirement for the PSK subsystem shall be .99. A failure shall be defined as the loss of performance as specified above. A failure of a signal processing function that is not an active element of a particular operational mode shall not be considered a failure as defined in this paragraph. The mean time to repair shall not exceed 15 minutes. Attention shall be given to modular construction according to function and fault location and isolation techniques in order to meet this performance without the need for complete equipment redundancy.

The input and output levels, and other parameters, are shown in Table 3-8. The clock is nominally a square wave alternating between zero and plus one. The 120 MHz clock is generated in such a manner that its positive going leading edges coincide with 120 Mbps data symbol changes. The 16 MHz clock is generated in such a manner that its positive going leading edges coincide with 16 Mbps data symbol changes. The relationship between these clocks is to be determined.

3.7.1.2 DATA RECORDING AND HANDLING SUBSYSTEM (DRHS)

The main purpose of the DRHS will be the acquisition of the EOS payload data. It shall include, but not be limited to, acquisition high density digital recorders (HDDR), a switching terminal (ST) connecting the QPSK demodulator and signal conditioner (QDSC), QDSC and the HDRR units, EOS/PGS status formatter (SF), and a quick-look monitor (QLM). Figure 3-12 is a diagram of the DRHS.

Table 3-8 240 Mbps QPSK Demodulator and Signal Conditioner

MODULATION	QPSK OR OQPSK
INPUT LEVEL	-20 TO -75 dBm
INPUT CENTER FREQUENCY	700 MHz
FREQUENCY UNCERTAINTY	±100 kHz AT 700 MHz
IMPEDANCE	50 OHMS ±10%, UNBALANCED
PERFORMANCE	WITHIN 2 dB OF THEORETICAL WHEN DEMODULATING "PERFECT" SIGNAL
RATES	TWO 120 Mbps DATA STREAMS, OR ONE 120 Mbps, ONE 16 Mbps
OUTPUT CLOCK AND DATA	NORMAL OR INVERTED
	RISE AND FALL TIMES ≤ TBD ns INTO 75 ohm ±% RESISTIVE LOAD
	CLOCK RATES IN Hz EQUAL DATA RATES IN bps, TRANSITIONS SYNCHRONOUS WITH DATA
INTERNAL CLOCK STABILITY	1 PART IN 10^5/WEEK AND 1 IN 10^6/ SECOND

(2)5T-8

The DRHS shall have the following minimum configuration.

- Three high density digital recorders
- One switching terminal
- One EOS/PGS status formatter
- One quick-look monitor

3.7.1.2.1 Acquisition High Density Digital Recorder

Each acquisition high density digital recorder (HDDR) shall meet the minimum requirements specified below:

- The acquisition HDDR shall be a high data rate recorder equipped with record and reproduce electronics sutiable for high density PCM recording.
- The acquisition HDDR shall accept and record serial NRZ-L input data at a 120 Mbps rate and a coherent clock with a frequency of one full cycle per bit period. The on-line storage capacity of the acquisition HDRR at this input rate shall be a minimum of 15 minutes.
- The acquisittion HDDR shall output serial NRZ-L data at a 120 Mbps or slower rate, and a coherent clock with a frequency of one full cycle per bit period.
- The bit error rate (BER) experienced when reproducing data shall not exceed 1×10^{-6} when vendor recommended tape is used. This shall be true whether or not the tape is reproduced on the recording machine or on a different machine of the same type. The computation of bit errors shall include the effects of machine error, tape drop outs, and bit slippage due to both error sources.

- The record/reproduce speed ratio shall be 10:1 or greater with no degradation of the BER.

- The acquisition shall accept and record time-of-day information, thus referencing the input data to its recording time.

- All variation in the output data due to time base error (TBS), including wow and flutter shall not exceed .01 percent deviation from the nominal value.

- The acquisition HDDR shall contain means for monitoring the performance of the recorder and of each channel.

- The servo system shall use either an internal tachometer, or a prerecorded signal on a tape track as a reference, and shall switch reliably from one to the other.

- The life of the head assembly shall be 1000 hours or longer.

- The acquisition HDDR shall be designed and configured to permit early diagnosis of malfunctions, and rapid and easy replacements of faulty parts and/or subassemblies. The availability of the HDDR shall be .995

  where availability = $\frac{\text{MTBF}}{\text{MTBF + MTTR}}$

- The HDDR shall be provided with remote control and sensing capability for use by external equipment such as a computer. The remote control and status functions shall include, but shall not be limited to the following:

Control	Status
Power On/Off	Power On
Speed Selection	Speed
Stop	Forward
Forward	Reverse
Reverse	EOT
Fast Rewind	Fault
Record	Tape Sync
Reproduce	Loss of Data
Local/Remote	

3.7.1.2.2 Switching Terminal

The switching terminal (ST) shall meet the following requirements:

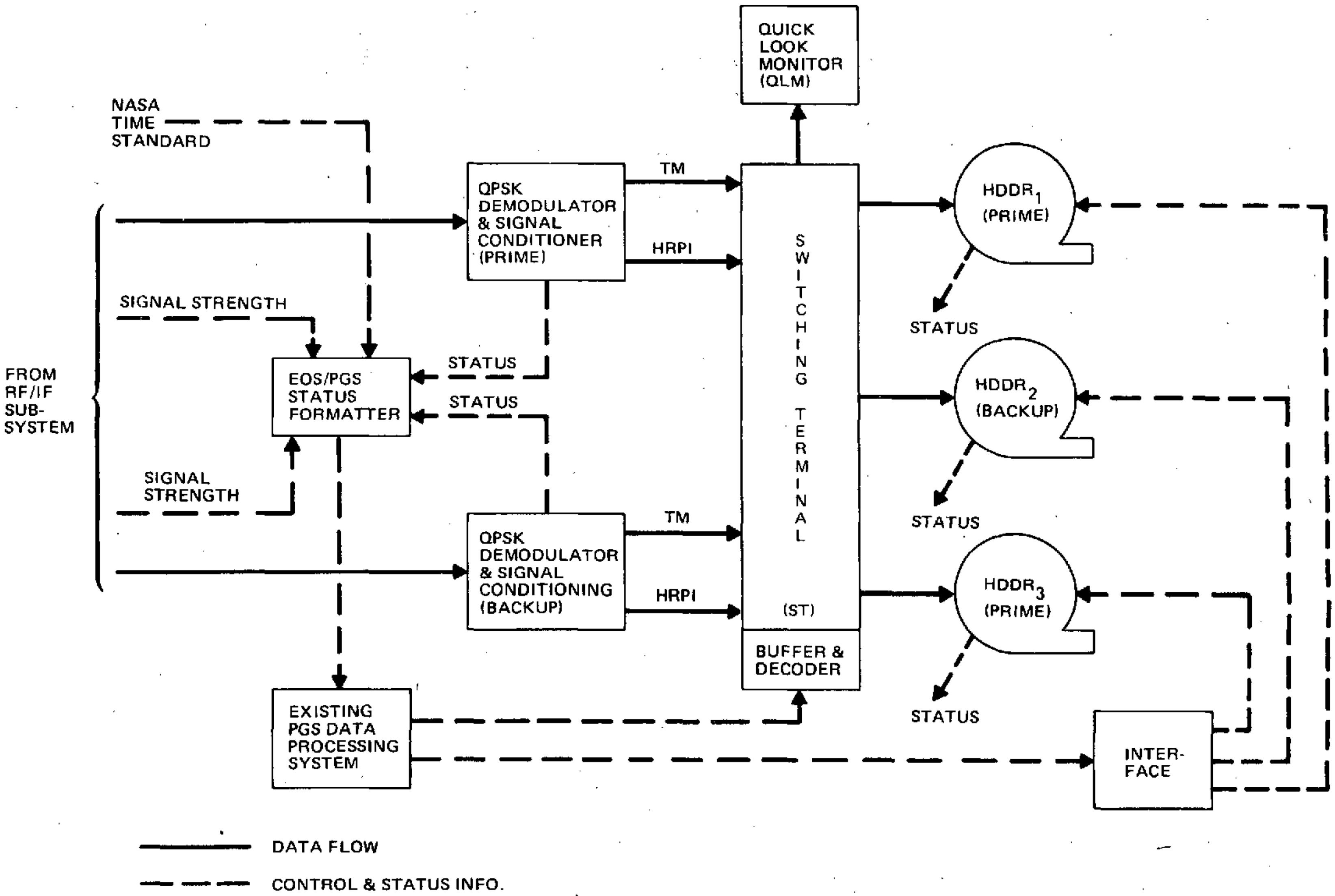


Fig. 3-12 PGS Data Recording and Handling Subsystem

- The ST shall be configured to switch one of two NRZ-L serial digital baseband signals with coherent serial clock to any one, any two, or any three HDDR units. Only one signal and its clock shall be connected to any HDDR at any time.

- The two input signal data rates will be 100 Mbps and 16 Mbps for TM and MSS, and 100 Mbps and 100 Mbps for TM and HRPI. The ST shall not degrade the BER of the data.

- The switching action of the ST shall be under computer control with manual back-up.

- At least one command shall be interpreted by the ST as a request for switching status.

- The ST shall transmit computer control words to the HDDR units, and receive status indication from them.

- The ST shall distribute a NASA 36-bit time of day (TOD) clock signal to any one, any two, or all three HDDR units.

3.7.1.2.3 Status Formatter

The status formatter shall monitor status information from the acquisition HDDR's, the Demodulators, the Receiver/Downconverter, and convert this information into a format compatible with the PGS data processing systems. The information monitored shall include but not be limited to:

- Sync lock status of the signal conditioners.

- Signal strength indication of the receiver/downconverter

- Operational status of the acquisition HDDR's as specified in Paragraph 3.7.1.2.1 (2).

3.7.1.2.4 Quick-look Monitor (QLM)

The quick-look monitor shall consist of a frame memory and a CRT display on which a selected subject of the video data can be displayed, while the acquired data is being recorded.

3.7.1.3 Command/Tracking

3.7.1.3.1 Command Message Transmission

Command message transmission to the Observatory shall be accomplished by the STDN ground stations via the Spacecraft Command Encoders (SCE's). Command messages shall be transmitted to the STDN stations by the PCC realtime during a contact period or non-realtime to be stored by the STDN station for later transmission to the Observatory.

3.7.3.1.3.2 Tracking

Tracking of the Observatory by the STDN ground stations shall utilize the tone ranging system. The tracking information obtained shall subsequently be transmitted to the GSFC Orbit Determination Facility for further processing.

3.7.2 CENTRAL PROCESSING SYSTEM

Figure 3-13 is an overall diagram of the CPS. Figures 3-14 through 3-16 show three possible system concepts for the ICPS, the FCPS, and a possible combined concept involving no change in basic configuration between ICPS and FCPS for the Level II/III processing. It is the intent of NASA that selection of a configuration for the ICPS shall be made on the basis of minimizing the total cost of the ICPS and the cost of expansion to the FCPS.

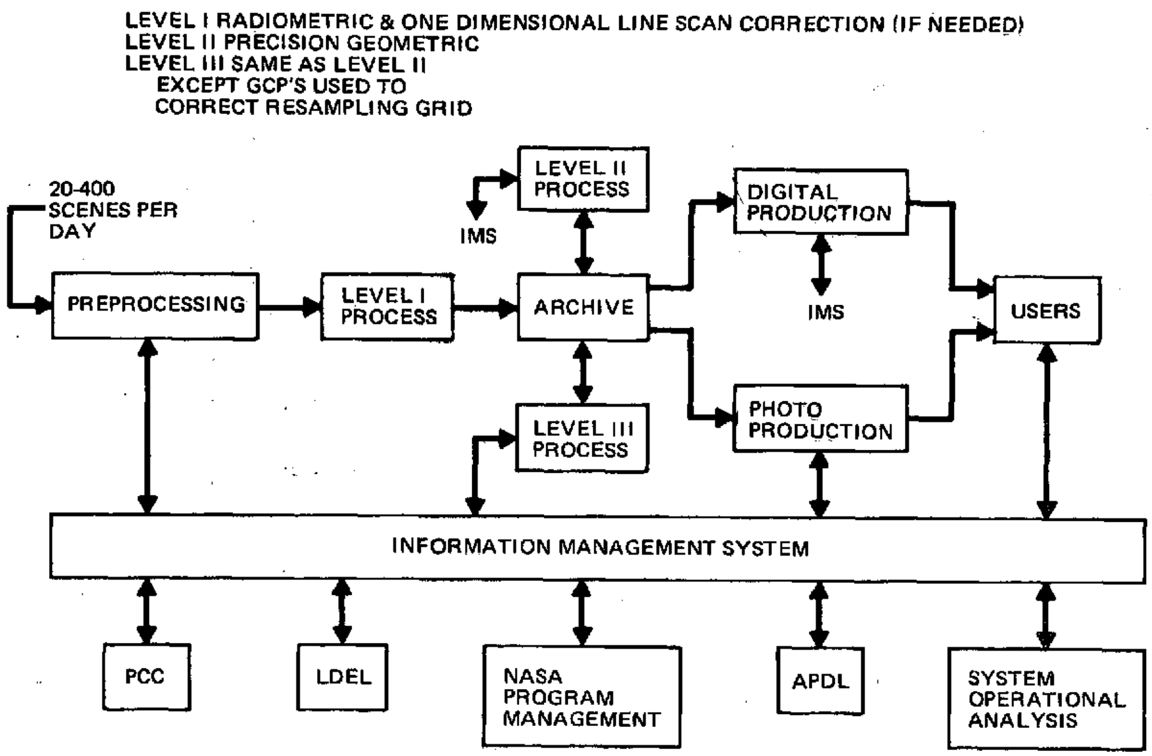
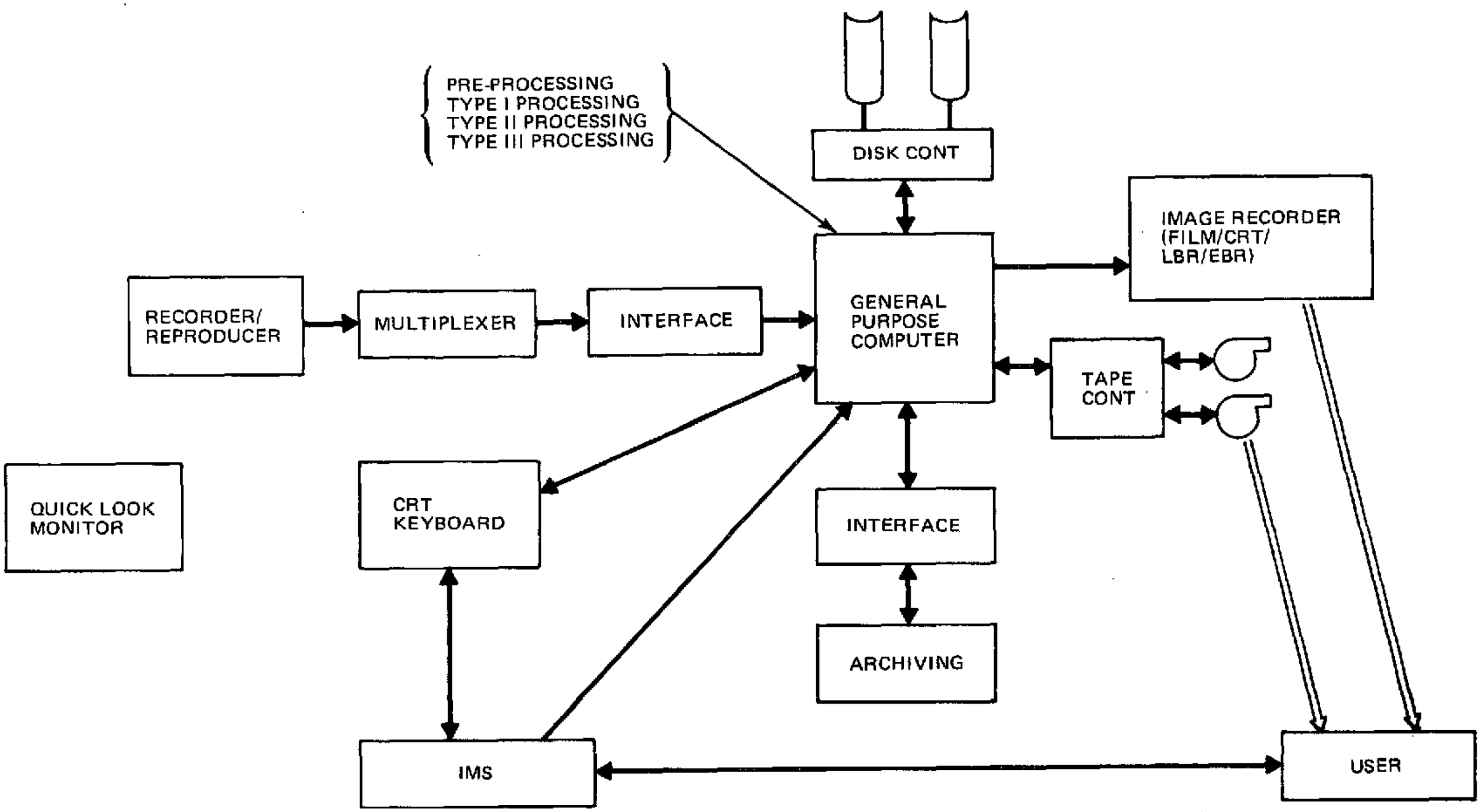


Fig. 3-13 General Structure of CDPF



(2)5-14

Fig. 3-14 ICPS Concept

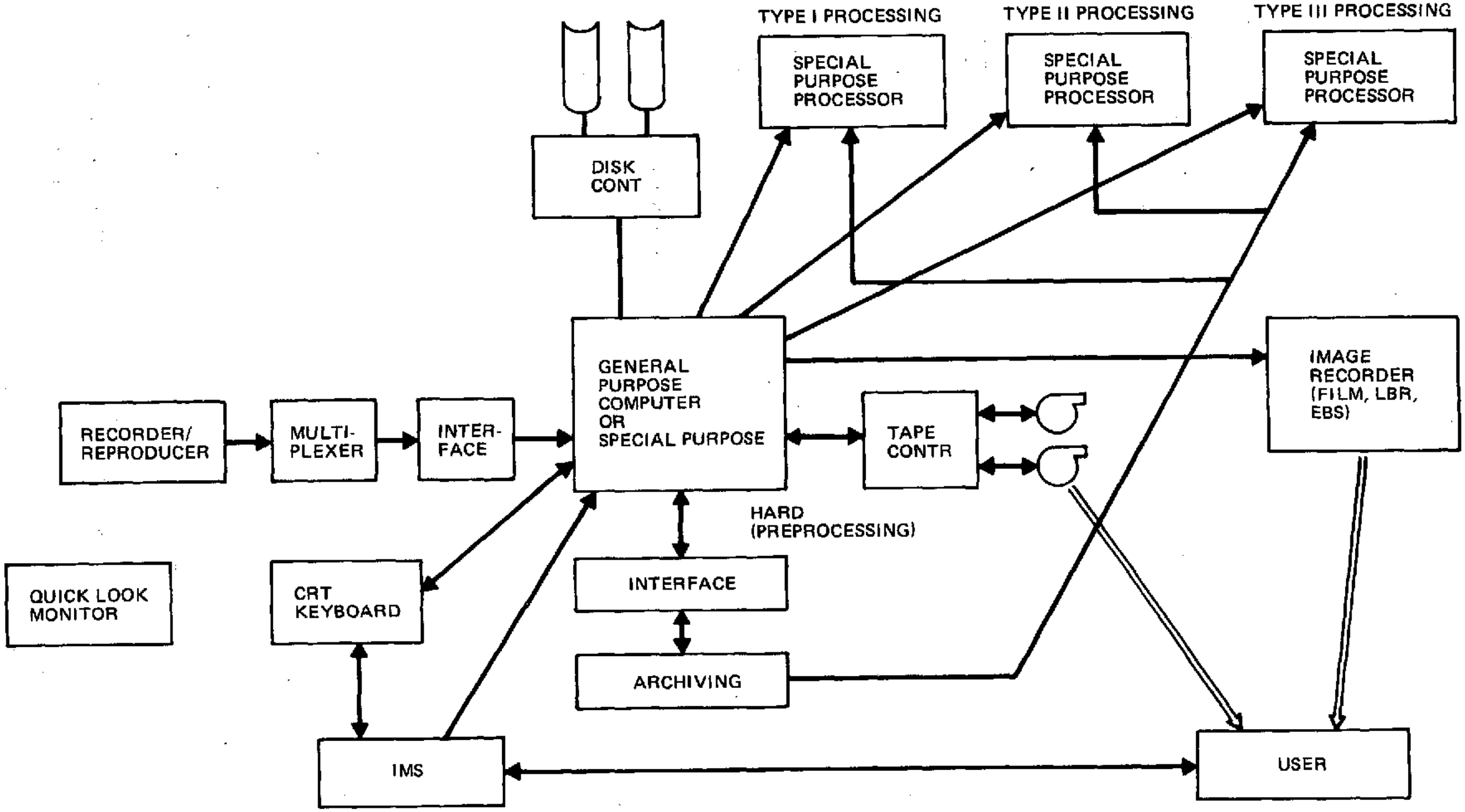
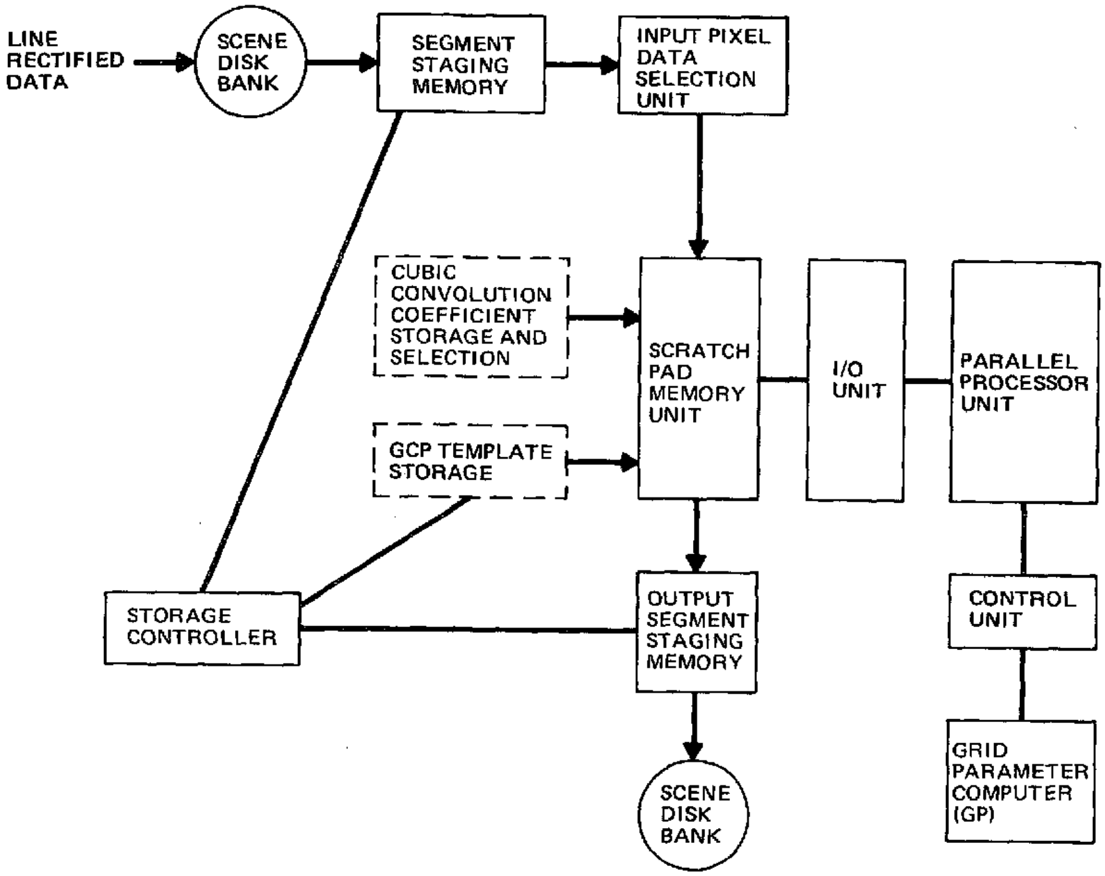


Fig. 3-15 FCPS Concept



(2)5-16

Fig. 3-16 Level II/III Parallel Processor Configuration Concept

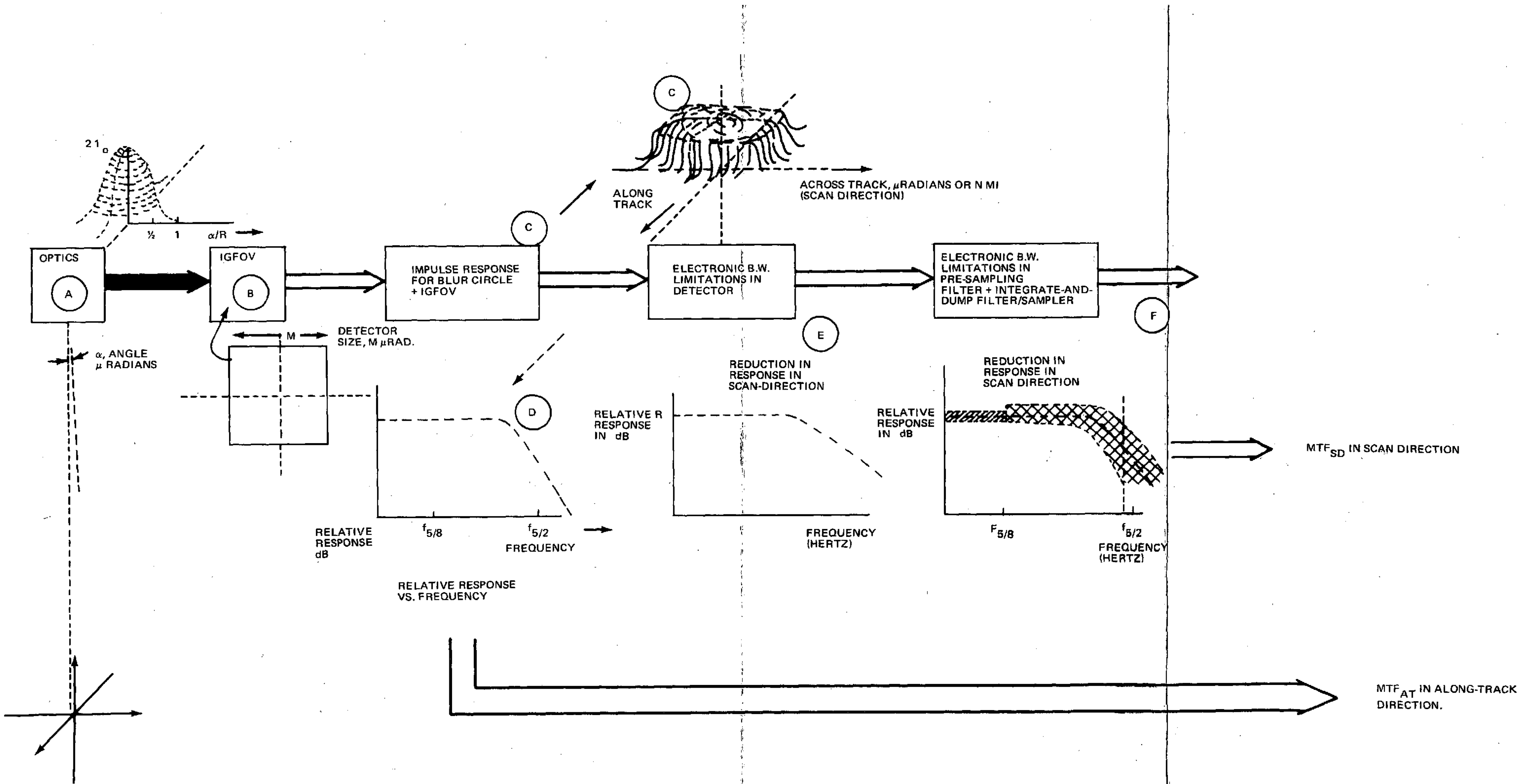
3.7.2.1 OUTPUT PRODUCT QUALITY

Overall quality shall be defined in the three areas:

- Resolution Accuracy
- Geometric Accuracy
- Radiometric Accuracy.

3.7.2.1.1 Resolution

The basic resolution of the Thematic Mapper (TM) will be defined by a model similar to that shown in Fig. 3-17. This model will allow analyses and/or simulation of the image-taking system up to the point where the sensor outputs are digitized and converted to the high-rate digital data sequence. From this point on, until final products are generated, it is the responsibility of the CDPF to preserve the basic resolution of the system within certain tolerances.



(2)5-17

Fig. 3-17 Along Track and Cross Track MTF'S at Input to CDPF

The basic resolution of the sensor system will be provided in terms of two modulation-transfer functions (MTF's), one applying to the scan direction (approximately west-east), and the second applying to the Observatory along-track direction (approximately north-to-south).

The blur-circle of the optics (Fig. 3-17 A) convolved with the response of the (generally rectangular), non-zero size detector aperture B (sometimes referred to as IGFOV, instantaneous geometric field of view), yields an overall impulse response C of the blur circle + IGFOV. The Fourier transform of this impulse response D gives relative response versus "spatial frequency" when account is taken of scan rate to convert μradians/second to line pairs of picture information on the ground.

The resultant MTF D is a reasonable approximation to the MTF in the along-track direction. Non-zero detector response time electronic bandwidth limitations E, plus the bandwidth limitation of the presampling filter integrate-and-dupm/sampling circuit F combine to degrade the MTF further in the scan direction.

The CDPF shall preserve the two MTF characteristics (MTF_{sd} and MTF_{at}) within the tolerances specified in Paragraph 3.2.1.2.3 up through the digital processing. The primary contributor to additional MFT degradation is likely to be the two dimensional interpolation performed during resampling.

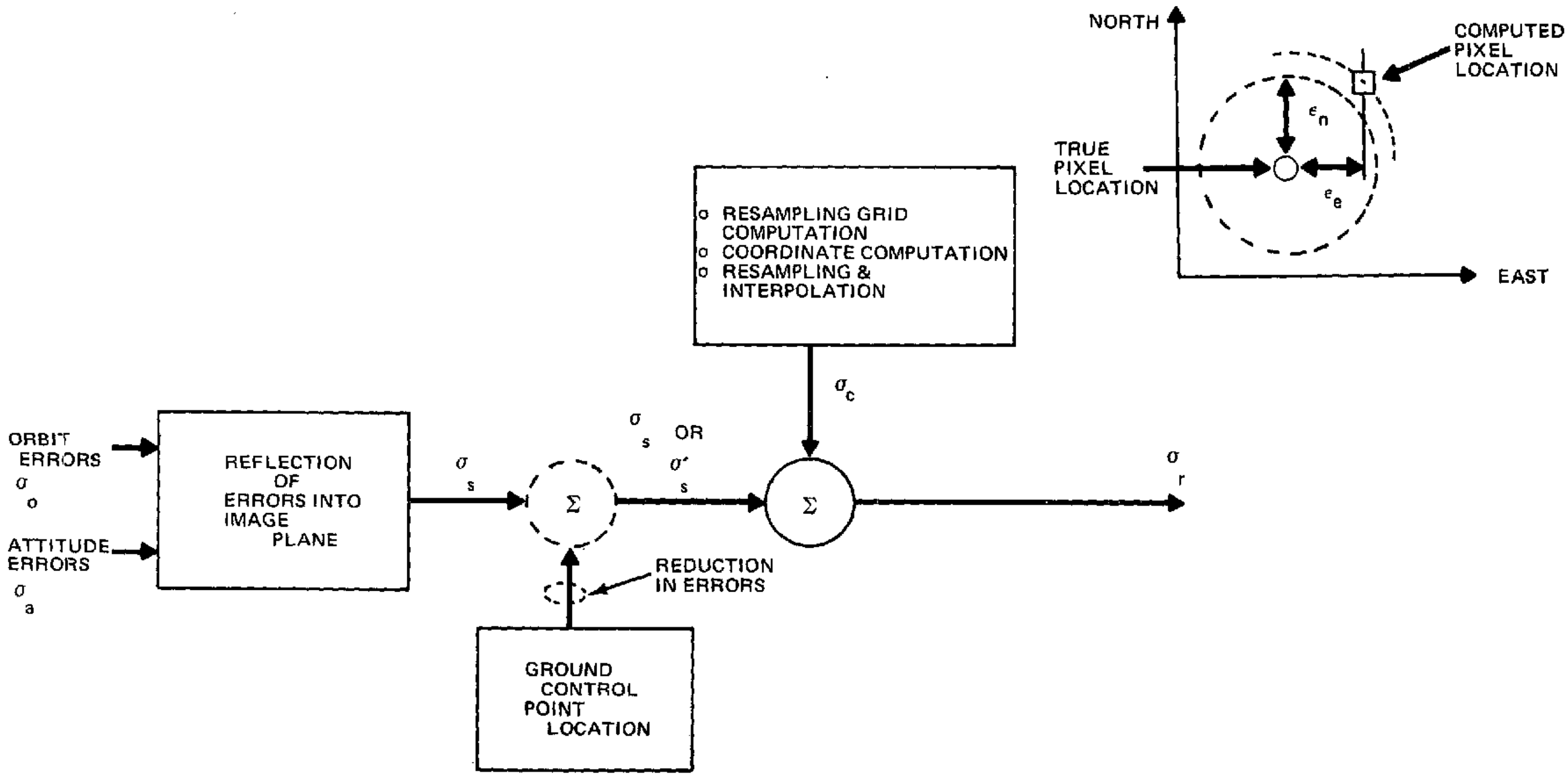
Additional degradation to the MTF is allowed during photo product generation as specified in Paragraph 3.2.1.2.3. This additional smearing of the images is primarily due to the LBR spot size as defined in Paragraph 3.2.1.2.3, with a relatively small additional degradation due to the film characteristics.

3.7.2.1.2 Geometric Accuracy

Geometric, or mapping, accuracy of the EOS images is determined primarily by:

- System errors (ephemeris, altitude, scan linearity), and the degree to which these errors can be corrected
- Natural errors (earth curvature, and earth rate), and the degree to which these effects can be modeled and corrected
- Errors incurred in the processing in the CDPF either due to the basic precision of the calculations or to the approximations that must inevitably be made in processing the digital image data.

The combination of these errors into an overall model of the geometric accuracy of the TM images is shown in Fig. 3-18.



(2)5-29

Fig. 3-18 General Model for Geometric Accuracy

Total circular error in the image is made up of

$$\sigma_T = \left[\sigma_s^2 + \sigma_c^2\right]^{1/2}$$

where:

$$\sigma_T = \left\{\overline{\epsilon_N^2} + \overline{\epsilon_E^2}\right\}^{1/2} \quad ; \text{ with } \overline{\epsilon_N^2} \text{ and } \overline{\epsilon_E^2}$$

representing mean square northing and easting errors, respectively

σ_s ≡ worst case circular error in pixel location due to errors in spacecraft ephemeris and attitude

σ_c^2 = worst cast circular error in pixel location due to processing.

When ground control points (GCP's) are used to obtain better estimates of ephemeris and attitude, the residual combined error due to both effects is denoted σ_s^1.

The errors due to ephemeris (σ_0) and altitude (σ_a) combine to give worst case σ_s for 705 Km orbit altitude as:

$$\sigma_s \approx \left[1.65\ \sigma_0^2 + \sigma_a^2\right]^{1/2}$$

where:

σ_0 = rms orbit error in altitude, along-track or across-track distance, expressed in meters

σ_a = rms attitude error about pitch, roll, and yaw axes expressed in μ r.

For equal root mean square northing and easting errors in the image of 450, 170, or 15 meters, the allocation of errors among the processing-related (σ_c), and non-processing related (σ_s or σ_s') factors are summarized in Table 3-9.

Table 3-9 Allocation of Errors

MAXIMUM (SPEC) VALUES OF $(\overline{\epsilon_N^2})^{1/2}$ AND $(\overline{\epsilon_E^2})^{1/2}$ (NORTHING AND EASTING R.M.S. ERRORS)	NORTHING AND EASTING ERRORS ACTUALLY BUDGETED	SPACECRAFT ATTITUDE ACCURACY, σ_a (EACH AXIS)	EPHEMERIS ERROR, EACH OF THREE COMPONENTS		$\sigma_c/\sqrt{2}$ NORTHING AND EASTING ERRORS DUE TO GROUND PROCESSING
			MEASURED	PREDICTED	
450M	393M	207μR	–	357M	10.6
170M	165M	207μR	76M	–	10.6
15M	15M	*	*	–	10.6

* σ_s' RESIDUAL ERROR ≤ 15 METERS AFTER CORRECTION ϵ USING GROUND CONTROL POINTS

(2)5T-12

3.7.2.1.3 Radiometric Accuracy

A model for radiometric accuracy of the Thematic Mapper will be provided as shown in Fig. 3-19. This model will include the basic detector noise (A), the presampling filter (B), as well as A/D conversion (C), which all contribute to radiometric errors in the digital image data collected by the sensor. Note that if a nonlinear quantizer is used at (C), then an inverse nonlinearity must be included in the processing

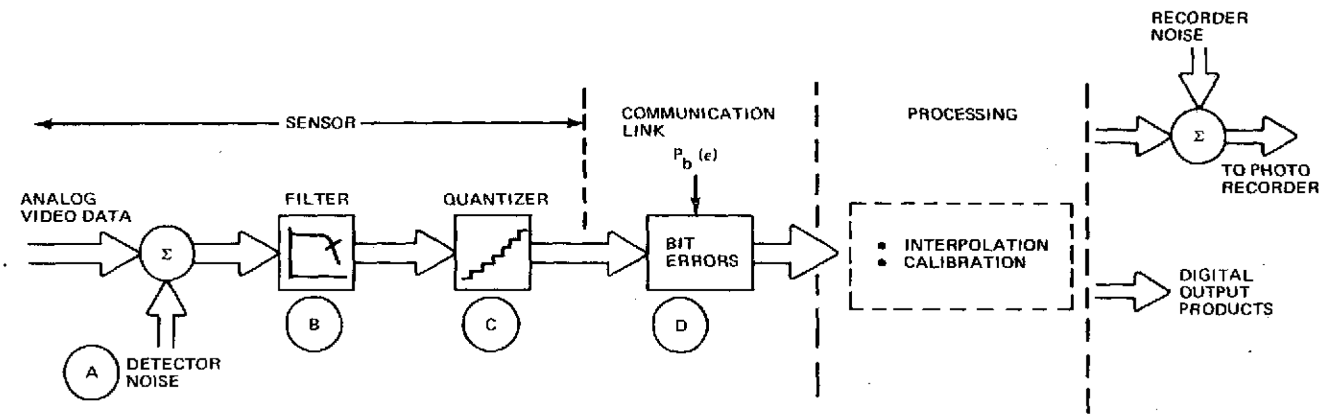


Fig. 3-19 Error Model for Radiometric Accuracy

(2)5-18

Uncorrected bit errors on the communication link, (D), will also contribute to radiometric errors in the individual picture samples.

Given the definition of radiometric fidelity of the digital image data at the input to the CDPF, the digital products and the photo products shall be generated with radiometric accuracy as defined in Paragraph 3.2.1.2.3.

3.7.2.2 PROCESSING

The processing levels defined in Paragraph 3.2.1.2.2 will be described in greater detail in this section. The details will first identify the functional requirements in that level of processing followed by one possible (out of many) way of attaining those functional requirements.

3.7.2.2.1 Level I Processing

The basic functional requirement of the Level I processing shall be to correct the inaccuracies in the light intensity values obtained from the detectors. This is called radiometric correction. In addition to this basic functional requirement, Level I processing includes correction for any non-linearities in the motion of the scanner along the scan direction.

If n = number of light intensity bits assigned to each pixel a simple table look up, with table containing the possible 2^n output high intensity values for 2^n input light intensity values (1 to 1 correspondence) will be sufficient to obtain radiometric correction. One dimensional interpolation shall be performed to correct for scan non-linearity.

3.7.2.2.2 Level II Processing

The functional requirement of the Level II processing shall be to obtain geometric correction that uses the predicted Observatory location and attitude data and also eliminates the errors introduced by earth rotation and earth curvature.

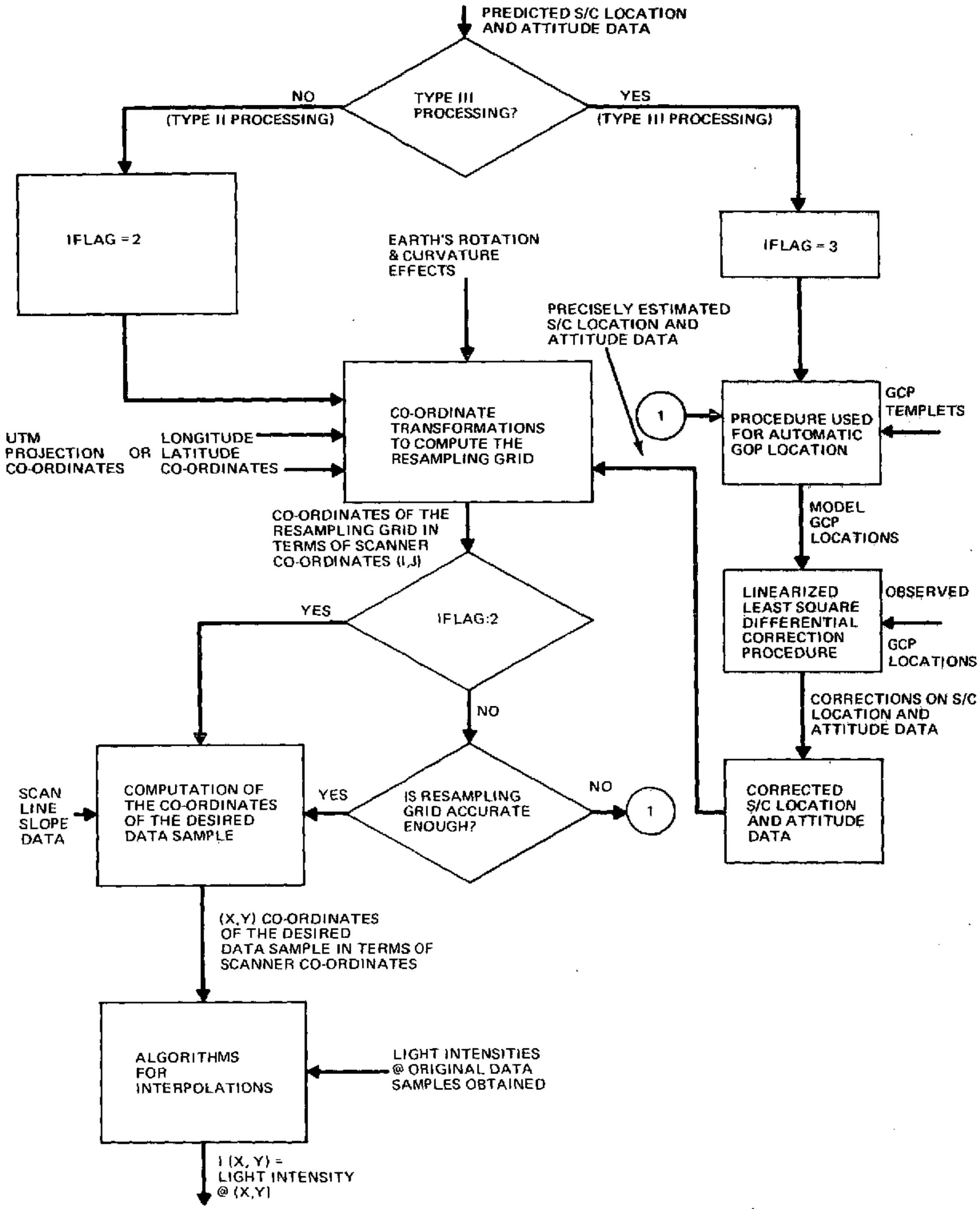
Level II processing shall be applied to the data that has already gone through Level I processing. A resampling grid, giving the image line and pixel coordinates corresponding to the intersection points of a geographic grid shall be computed using predicted Observatory location and attitude data. This grid shall subdivide the area of one image frame into 10-30 lines in both the horizontal and vertical directions. Interpolation within this grid will be used to be an adequate approximation to the mapping of any location on the surface of the earth (in terms of either the UTM coordinates or the longitude-latitude coordinates) into the pixel number - line number of the scanner coordinates. The light intensity at the desired output data sample location shall then be obtained using any one of the 3 two dimensional interpolation algorithms specified in Paragraph 3.7.2.3.

Figure 3-20 is a summary flow chart of Level II processing.

3.7.2.2.3 Level III Processing

The functional requirements of the Level III processing are the same in nature as those in the Level II processing. In the Level III processing a precision geometric correction shall be obtained using precisely estimated Observatory location and attitude data with the help of ground-control points (GCPs). The errors introduced by earth rotation and earth curvature shall again be eliminated as in the Level II processing.

Level III processing shall be applied to data that has already gone through Level I processing.



(2)5-19

Fig. 3-20 Summary Flow Chart for Level II and Level III Processing

The resampling grid shall be obtained in the same manner as in the Level II processing. Refinements in the Observatory location and altitude data and in the resampling grid itself shall be obtained by using the GCP locations. This procedure will require modeling of the Observatory motion, and may require iteration, until the desired accuracy in the position location is obtained (see Fig. 3-20). Once the refined resampling grid is obtained, the same procedure as outlined in the Level II processing shall be used to obtain the locations of the desired data samples and the corresponding light intensities.

3.7.2.3 INTERPOLATION ALGORITHMS

The CPS shall, as a minimum set of options, allow the use of any one of three interpolation algorithms during Level II or Level III processing. The three algorithms are: 1) nearest neighbor interpolation, 2) bilinear interpolation, and 3) cubic convolution.

Given the location x, y of a desired output pixel in an array of original data samples:

$$i \Delta x \leq x < (i+1) \Delta x$$

$$j \Delta y \leq y < (j+1) \Delta y$$

where:

i = appropriate line no.

j = appropriate pixel no.

Δx = spacing between lines

Δy = spacing between pixels

then the three interpolation algorithms are defined as follows:

1. <u>Nearest Neighbor Interpolation</u>

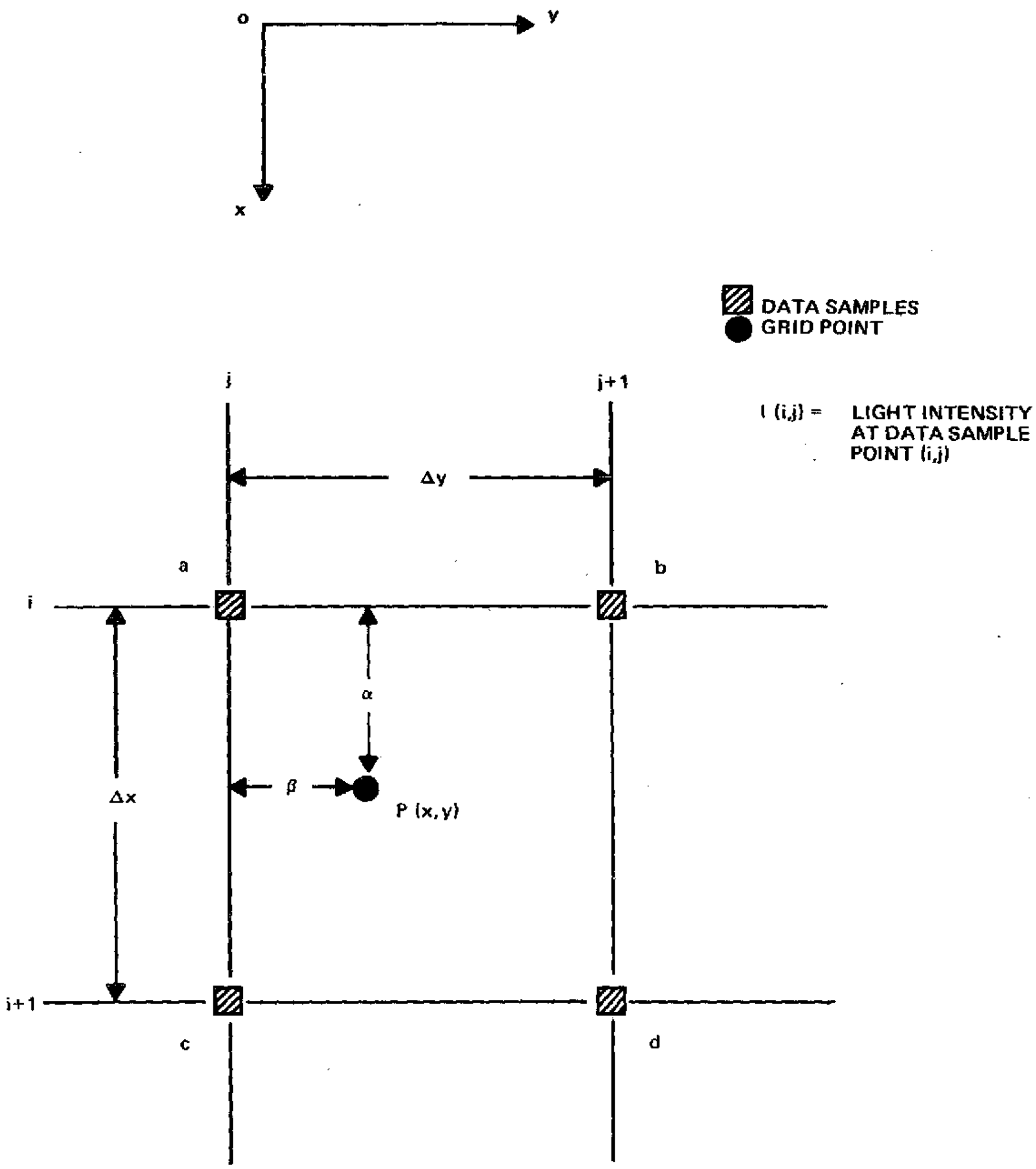
   This interpolation algorithm involves finding the true data sample closest to the desired data sample location (x, y) and transferring the light intensity of that true sample to (x, y) (see Fig. 3-21). This is:

   $I(x, y)$ = light intensity at (x, y)

   = light intensity of the nearest true sample

2. <u>Bi-Linear Interpolation</u>

   This interpolation algorithm involves finding the 4 true data samples closest to (x, y) and obtaining $I(x, y)$ as a weighted sum of the light intensities of these 4 true data samples (see Fig. 3-21). Bi-linear interpolation is made up of three linear interpolations, 2 in the x-direction and 1 in the y-direction (or vice versa).



(2)5-20

Fig. 3-21 Geometry for Nearest Neighbor and Bilinear Interpolations

Specifically,

$$\begin{aligned} I(x,y) &= (1-\beta)\, I\,(x,j) + \beta\, I(x,j+1) \\ &= (1-\beta)\left[(1-\alpha)\, I\,(i,j) + \alpha\, I(i+1,j)\right] \\ &+ \quad \beta\left[(1-\alpha)\, I(i,j+1) + \alpha\, I(i+1,j+1)\right] \end{aligned}$$

where:

$\alpha = x - \text{int}(x)$

$\beta = y - \text{int}(y)$

3. Cubic Interpolation

Cubic interpolation involves the use of the appropriate 16 true data samples to obtain I(x, y) using the interpolation polynomial given by:

$$
\begin{aligned}
f(\Delta) &= 1 - 2|\Delta|^2 + |\Delta|^3 && \text{for } 0 \leq |\Delta| < 1 \\
&= 4 - 8|\Delta| + 5|\Delta|^2 - |\Delta|^3 && \text{for } 1 \leq |\Delta| < 2 \\
&= 0 && \text{for } |\Delta| \geq 2
\end{aligned}
$$

where:

$\Delta = \Delta x$ or Δy.

Interpolation can be performed first in x-direction using the above polynomial to obtain 4 numbers giving the light intensities at positions; (x, j-1), (x, j), (x, j+1) and (x, j+2); given by (see Fig. 3-22).

$$
\begin{aligned}
I(x,k) &= \left[1+\alpha(1-\alpha)\right]\left[(1-\alpha)I(i,k) + \alpha\, I(i+1,\ k)\right] \\
&\quad - \left[\alpha(1-\alpha)\right]\left[(1-\alpha)I(i-1,k) + \alpha\, I(i+2,\ k)\right] \\
k &= j-1,\ j,\ j+1,\ j+2
\end{aligned}
$$

Next, interpolation is performed in the y-direction using a formula similar to the above to obtain I(x, y) in terms of I(x, j-1), I(x, j), I(x, j+1) and I(x, j+2) given by:

$$
\begin{aligned}
I(x,y) &= \left[1+\beta(1-\beta)\right]\left[(1-\beta)\ I(x,j) + \beta\ I(x,\ j+1)\right] \\
&\quad - \left[\beta(1-\beta)\right]\left[(1-\beta)\ I(x,\ j-1) + \beta\ I(x,\ j+2)\right]
\end{aligned}
$$

Since cubic convolution is an approximation to a truncated, two dimensional, sin x/x interpolation, table look-up procedures can be utilized in lieu of the above expressions, to obtain the interpolation weights.

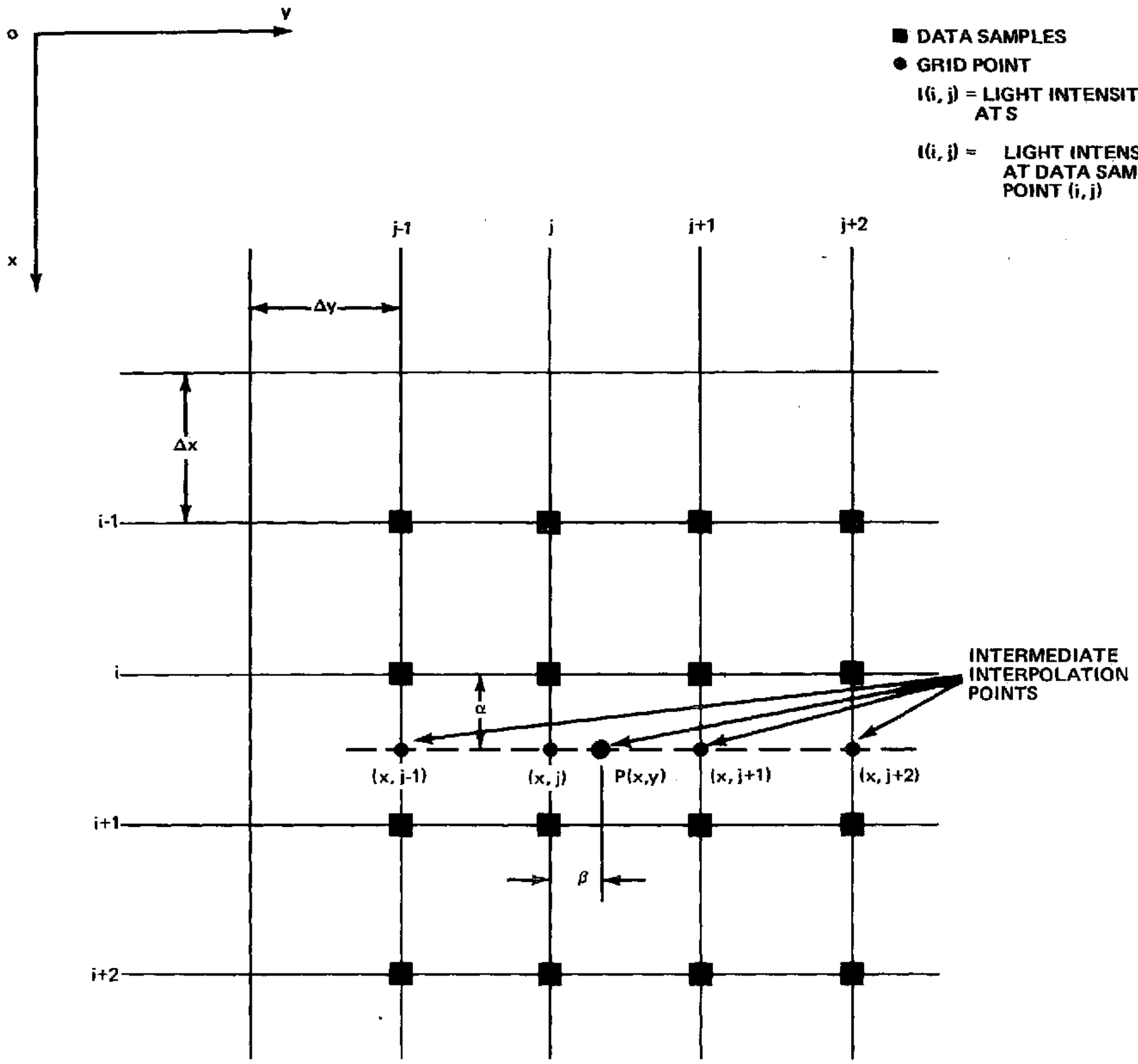
3.7.2.4 INFORMATION SERVICES SYSTEM

Figure 3-23 shows a functional diagram of the ISS.

3.7.2.4.1 Functions

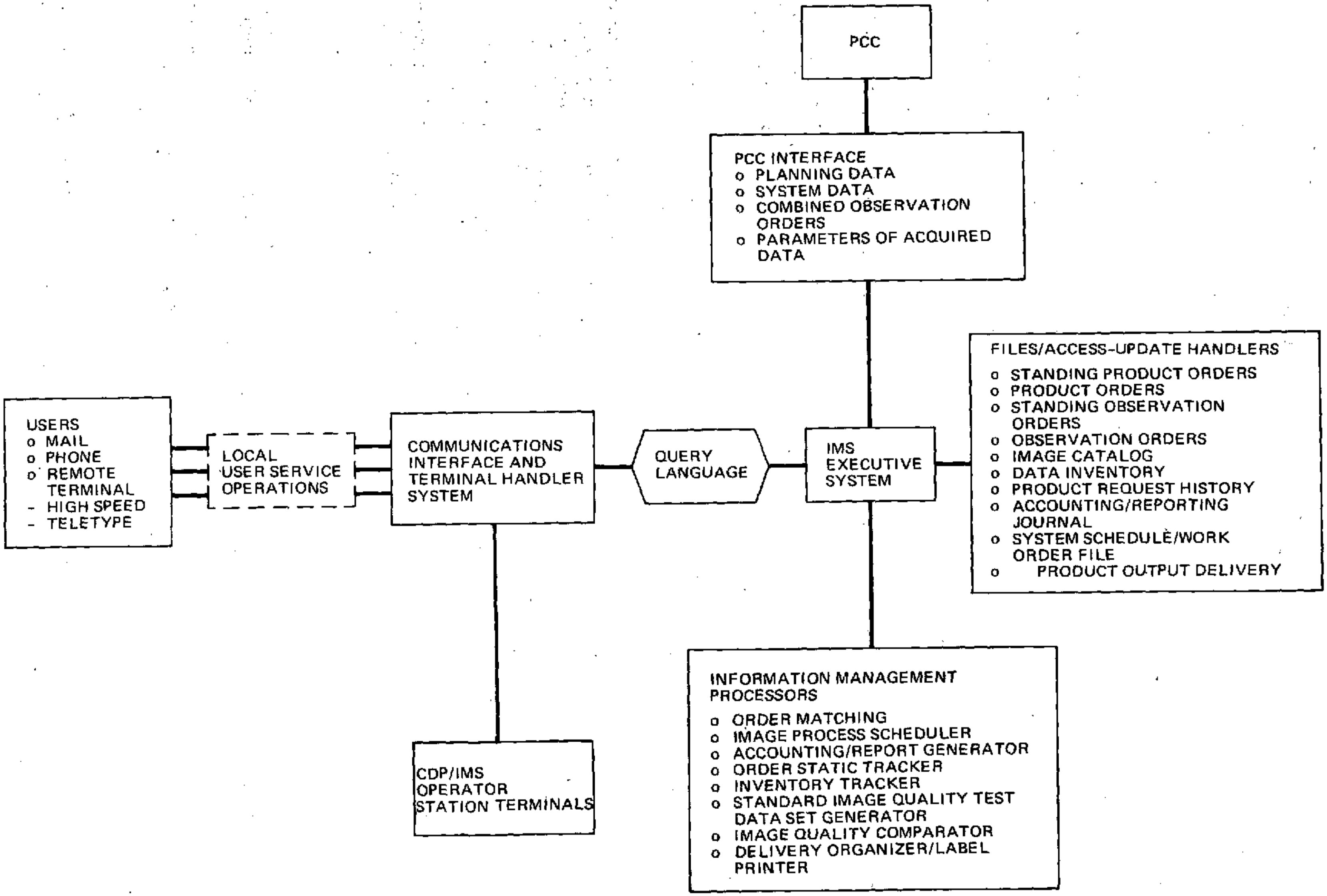
The functional areas defined in Paragraph 3.2.1.2.7 shall include capabilities and subfunctions as defined below:

- There shall be a communications interface, terminal handler system, and query language for interactive communication between the ISS and the users or CDP personnel. The system shall provide a sufficient number of ports and shall include sufficient hardware and software resources that a User is required to wait more than 1 minute for initial sign-on with probability no greater than .05, that a User is required to wait more than 2 seconds for a response to a terminal keyboard entry with probability no greater than .05, and that a User is required to wait more than 5 minutes for a response to a query inquiry with probability no greater than .05.



(2)5-21 **Fig. 3-22 Geometry for Cubic Interpolation**

For purposes of evaluating delays in system response, it may be assumed that there are 100 Users (in addition to any CDP personnel interacting with the ISS), that each User interacts with the ISS for a maximum of 15 minutes per week, that the probability of a User initiating a system interaction is uniformly distributed over the normal work week in the time zone in which the User is located, and that the Users are uniformly distributed over the region of the earth's surface covered by the satellite and intended to be served primarily by the CDP (instead of LUS systems).



(2)5-22

Fig. 3-23 ISS Functions

- There shall be an interface between the ISS and the PCC that shall handle all interface requirements between the CPS and the PCC. The interface shall be by means of access to a common random access peripheral device.

- The ISS shall maintain catalogs and inventories of all images and data acquired, processed, or generated by the system over its lifetime, to include:

  1. A catalog and directory of all acquired images, together with relevant data such as is required for annotation and is to be supplied by the PCC.

  2. An index containing image descriptors cross referenced to the catalog/directory of item (1). These descriptors shall be entered by users via the query language.

  3. An inventory and locator of all image originals and data products in the CDP and Photo Lab.

- The means for User ordering of observations and data products shall include:

  1. A means for placing standing orders for imagery to be acquired at some future date. The standing order system shall permit the User to request any available product type in any available format, except for such limitations as may be fully justified and approved by NASA.

  2. A means for requesting any image already acquired by the system, in any allowable format.

  3. A means for requesting future observations on any sensor subject to ground command. The system shall permit requests up to at least one year in advance of the observation and may require that the orders be placed in the system by a time no greater than one week in advance of the observation.

  4. The query language shall be used to provide a means for the user to inquire for confirmation of acceptance and other order status information.

  5. A means for establishing and implementing at least one special priority category for expedited service in addition to first-in-first-out (FIFO) which shall otherwise be the priority structure of the system.

- The ISS shall perform all workload scheduling for the CDP. The CDP operator interface shall be by means of query language interaction via local terminals.

- The ISS shall generate such standard data sets and work orders as may be required for diagnostic and test purposes to insure that the output product quality requirements are satisfied. The quantity of test data processed shall be equal to at least 1 percent of the total image data processing load.

- The ISS shall maintain such User accounts and produce such utilization reports as may reasonably be determined in coordination with NASA to be required for the proper functioning and administration of the EOS project.

- The ISS shall produce such mailing labels as may be required for proper distribution of data products to Users. The ISS shall include provisions for connecting digital image data product reproducing peripherals for the purpose of direct transmission of selected portions of images via the user terminal system. No impact on User terminal transmission rates is to be implied by the requirement for direct transmission provisions.

3.7.2.4.2 Implementation

The ISS shall be implemented on a general purpose digital computer of standard manufacture using off-the-shelf peripherals. The computer shall be supplied with a time-shared, multiprocessing, remote terminal handling operating system and all usual standard software support, including higher level language processors and utility software.

The query language and the processors implementing the requirements of Paragraph 3.7.2.4.1 may be of special design for the ISS.

3.7.2.5 OUTPUT PRODUCT GENERATION

3.7.2.5.1 Computer Compatible Tape

The computer compatible tape (CCT) shall be the standard 800 bpi, 1600 bpi, and 6250 bpi as defined by the ANSI standards - ANSI-X3.22-1973 for 800, ANSI-X3.39-1973 for 1600, and ANSI subcommittee document X3B1-658 for 6150 bpi. There shall be standard labeling as defined by ANSI-X3.29-1969 "Magnetic Tape Labels for Information Interchange". The tape shall be 9 track 1/2 inch wide magnetic tape. All characters shall be ASCII as defined by ANSI-X3.4-1968, "Code for Information Interchange".

The CCT's shall contain annotation for the images. This includes directional annotation given by the latitude and longitudinal coordinates, the northing and easting coordinates, the latitude and longitude of the nadir, and the sun angles. The Observatory information shall specify orbit revolution number and ground recording station in addition to its heading. The date of picture exposure, format center of the images, and radiometric correction table shall be specified. Recorded shall be the sensor and spectral band identification and all information to define the sizing factors of the image processing. The agency identification of where the tape was generated, the mission time, and scan information shall be described.

All frame and data formats shall be as defined in Paragraph 3.1.5.9.

3.7.2.5.2 User Product HDDR and HDDT

The HDDR's used for generating User products shall meet all requirements of the acquisition HDDR's with the exception of data rate and record/reproduce speed ratio. The

HDDR's shall utilize and/or produce high density digital tape (HDDT) recordings that meet the following requirements:

- The HDDT used in the subsystem shall be available from multiple sources
- The storage medium of HDDT shall be reuseable
- The width of the storage medium shall be 1 or 2 inch depending on the recording/archiving system in use
- The recording density of the HDDT shall be 10^6 (one million) bits/inch^2, or better
- The thickness of the storage medium shall meet the specifications of the HDDR
- The HDDT shall have at least 1,000 reliable read operations
- The HDDT shall have at least 5 years shelf life in controlled environment
- The formats shall be as defined in Paragraph 3.1.5.9

3.7.2.5.3 Digital to Photographic Transducer

The digital to photographic transducer shall be a laser beam recorder capable of producing a nine inch square image on 9-1/2 inch film. The raster size shall be 229 x 229 mm with a scan density of 27 lines/mm. The time to record a frame shall not exceed 30 seconds.

The film used in the transducer shall be of high quality with special characteristics for use in earth imagery/aerial photography applications, similar to Kodak type SO438.

3.7.2.6 ARCHIVE

The archiving subsystem shall be self contained and capable of operating independently of other processors. The control section of the archiving system shall handle I/O requests either from other host processors or from operators via connected terminals, and monitor overall system status. The system shall be modular such that it can be expanded with minimum modifications. The minimum system shall have the following capabilities:

- Minimum on-line storage capacity of 6×10^{10} bits (approximately 20 scenes)
- Minimum data transfer rate of 5.5×10^6 bits/sec
- Maximum seek time of 45 seconds (when media is fully recorded)
- Average seek time shall not exceed 15 seconds
- Error rate of 1 in 1×10^{11}.

The minimum system shall be modularly expandable to a minimum on-line storage capacity of 6×10^{11} bits (approximately 200 scenes). The system (minimum or expanded) shall be capable of operating in a fully automatic mode when supported by appropriate software and hardware.

3.7.3 PROJECT CONTROL CENTER (PCC)

3.7.3.1 PCC FUNCTIONAL CHARACTERISTICS

3.7.3.1.1 PCC Functional Diagram

The functional diagram (Fig. 3-24) for the EOS PCC is structured around the operational flow of the EOS mission. The diagram is oriented as follows:

- The Observatory is on the upper left
- The Central Processing Facility-Information Management System is on the right
- NASA-GSFC supporting activities (orbit determination, SCPS support, and MISCON) are on the bottom
- The large rectangular section in the middle area of the diagram represents PCC computing capability. This software may be centralized in a midi computer or decentralized in a grouped mini configuration.

3.7.3.1.2 Data Flow

The PCC shall process Observatory housekeeping data, which will arrive in real time via NASCOM links. Payload data will be sent directly to the CPF and Observatory tracking data will be sent directly to the NASA-GSFC orbit determination group.

3.7.3.1.3 PCC Functional Operations

The PCC functional operations are divided into three major cateogries:

- Mission Planning
- Mission Operations
- Mission Analysis

3.7.3.1.3.1 Mission Planning

The mission planning activity shall be centered around the PCC-IMS buffer, which is the disk file giving common access to both the PCC and the CDPF. Certain portions of the file shall be guarded in terms of write capability, and since this file is of critical importance in carrying out operations in both the CPPF and the PCC it must be heavily protected.

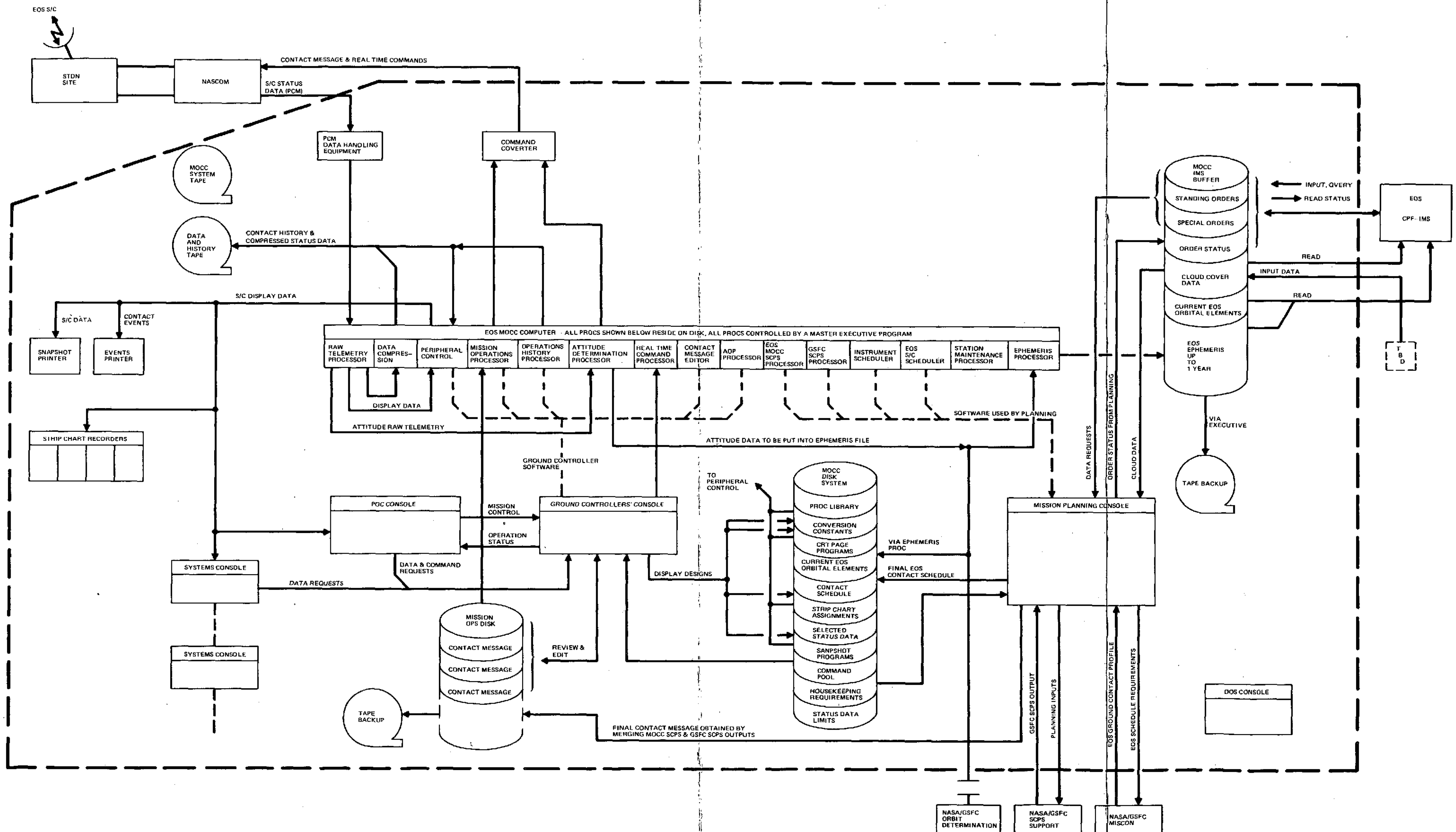


Fig. 3-24 EOS Mission Control Center Functional Diagram

The mission planning operation will start in the IMS area where EOS Users initiate their data requests. There will be two types of requests:

- Standing orders - requests for repetitive viewing of certain areas
- Special orders - requests for "single shot" viewing of selected areas.

Both of these requests will be fed into the PCC-IMS buffer for action during the planning phase. Since the readout process is non-destructive, standing orders only have to be entered once.

During the course of mission planning and execution, the status of the response to these data requests will be fed into the PCC-IMS buffer to handle user queries via the IMS.

The cloud cover data in the PCC-IMS buffer will be used for both planning and analysis purposes. The source of this data is yet to be determined, but there are several possibilities at present:

- Standard NOAA weather forecasts
- Nimbus spacecraft data
- SMS data.

The current Observatory orbital elements will be placed in the PCC-IMS buffer for the purpose of planning activities within the IMS. The ephemeris file is a catalog of the most accurate positions available for the Observatory versus time. This data will be used in the processing of payload data, and it will be supplied via standard channels from the NASA/GSFC orbit determination group. Orbit prediction is of critical importance to the EOS, and it is for this reason that it shall be done outside the CDPF area at the standard GSFC facility. The spacing of the ephemeris points must be close enough to allow the CPF to make accurate interpolation between these ephemeris points via very simple orbit propagation techniques.

Mission planning shall be done at the Mission Planning Console. This is the station where the overall coordination of the planning activity shall take place. The operations at this console shall be as follows:

- There shall be an interface with NASA/GSFC MISCON for the process of determining the ground contact profile for the Observatory. The net result of this activity will be a contact schedule resident on the PCC disk. This schedule will be updated once per week.

- There shall be two Support Computer Program Systems (SCPS)
  - Within the PCC using PCC computers
  - External to the PCC using standard NASA/GSFC SCPS support.

As much SCPS activity as possible shall be done within the PCC, but where duplication of extensive already existing capabilities would result, the already existing facility shall be used.

- Housekeeping functions for the Observatory shall be entered via the Mission Planning Console
- The contact messages for each ground contact shall be prepared by merging the various discrete planning results. These contact messages shall then be placed on the Mission Operations disk.

The last step in the planning process shall consist of a careful review of each contact message by the appropriate PCC personnel. This review process shall be accompanied by an editing capability via the Project Operations Controllers (POC) and the Ground Controller. This editing capability is particularly significant since it shall permit last minute changes in the contact message without requiring a complete SCPS recycle.

3.7.3.1.3.2 Mission Operations

Mission operations shall be built around the real time contacts with the Observatory, including prepass and postpass configuration and checkout activities. These real time operations shall center around two areas:

- The Project Operations Controller (POC) Console - The POC shall be the individual charged with complete responsibility for the safe and effective operation of the Observatory during each pass. During the pass he has the responsibility and authority to make all decisions related to this effort. This console shall be the focal point of the real time operation, and the design emphasis on the console must include an effective and complete data and operational display.
- The Ground Controller (GC) Console - The GC shall be the individual who operates the PCC during the real time contact. He shall have the responsibility to implement the contact message, and to respond to all POC direction for action, consistent with the current capabilities of the PCC.

The POC is also assisted by a group of subsystem specialists who monitor Observatory performance during each pass.

At the start of the real time operations the ground controller shall at the POC's direction, cause execution of the appropriate contact message.

In terms of data flow, the raw incoming telemetry shall be fed through the PCM equipment, and then the serial data stream shall be stored in the computer memory; the peripheral control shall drive the console displays, printers, and strip chart recorders.

The console displays shall be centered around interactive CRT's, with a snapshot printer, event printer, and strip chart recorder as backup. Via the interactive CRT each analyst shall be able to call up the data most pertinent to the current situation. It shall also be possible to easily design a new CRT page and input this new page (via the GC) onto the PCC system disk. This feature is of special importance when handling a Spacecraft problem.

3.7.3.1.3.3 Mission Analysis

The mission analysis phase follows the real time operations phase. These analyses will lead toward the generation of documents as defined in Paragraph 3.4.3. In general, the overall analysis activity concentrates on three main areas:

- Analysis of Spacecraft anomalies
- Characterization and quantitization of Spacecraft performance
- Preparation of improved operating procedures.

3.7.3.1.3.4 Housekeeping Data Analysis

Computer programs developed for housekeeping data analysis shall be oriented toward general data handling capabilities such as stripping out selected parameters, data tabulation, plotting routines, and provision of entry points for analyst supplied computational routines

The development of specific mission peculiar computer programs for analyzing housekeeping data shall be avoided, except where such routines are critical to safe and efficient operation of the Observatory.

3.7.3.2 CONFIGURATION

(See Fig. 3-25)

3.7.3.2.1 Communication and Data Acquisition Area

The Communication and Data Acquisition area shall consist of that equipment necessary to interface the PCC with the Primary Ground Stations. This equipment shall include the following items:

- Data Operations Supervisor Console
- Modems
- PCM Bit Synchronizer
- PCM Frame Synchronizer
- Analog Magnetic Tape Recorder
- Front End Processor Interface Unit.

3.7.3.2.1.1 Data Operations Supervisor Console

The Data Operations Supervisor Console shall be a low-boy console which shall house the necessary equipment to condition and monitor the incoming PCM telemetry data and outgoing command messages. It shall also contain the necessary patch boards for signal routing and distribution. All data entering or exiting the PCC shall pass through the DOS console. The equipment in the DOS console shall include but not be limited to the following:

- Analog and digital amplifiers
- Frequency meter
- Oscilloscopes
- Patch boards
- Interactive alpha-numeric CRT and keyboard
- Voice communication equipment (intercom, telephone)

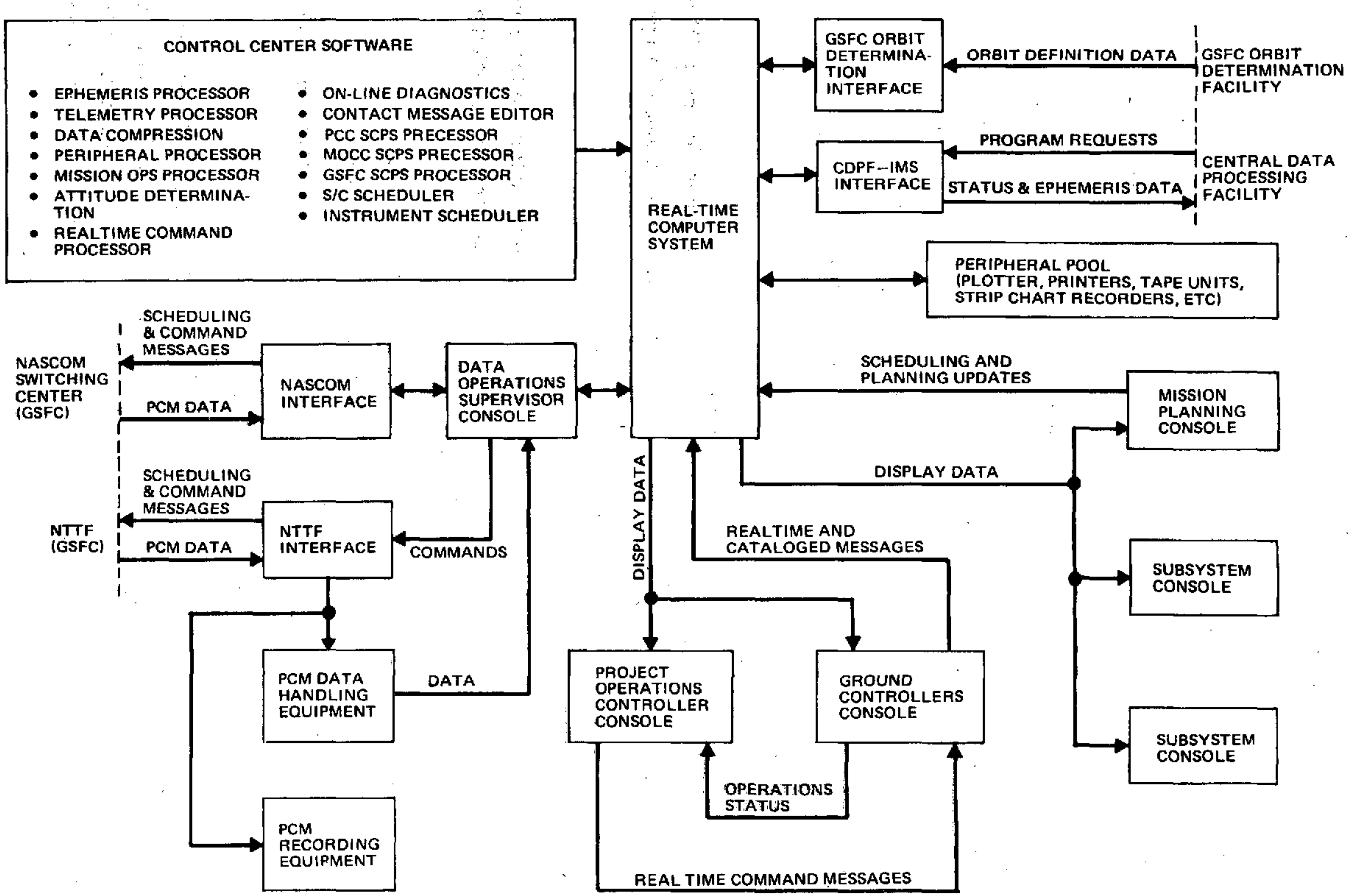
3.7.3.2.1.2 Modems

Modems shall be used to interface the PCC with the NASCOM Switching Center at GSFC. The modem shall be capable of full duplex operation at a maximum data transmission rate of 32 kilobits per second. Interface signal characteristics shall be as defined by the applicable NASCOM Interface Control Document.

3.7.3.2.1.3 PCM Bit Synchronizer

The PCM Bit Synchronizer shall meet the following specifications:

- Computer control of all parameters
- Minimum of 3 input sources



(2)5-2

Fig. 3-25 PCC Functional Diagram

- Input Codes - Standard IRIG-106-66
- Bit rate range - 100 bps to 1.2 Mbps
- Output - NRZ-L code and synchronized clocks.

3.7.3.2.1.4 PCM Frame Synchronizer

The PCM Frame Synchronizer shall meet the following specifications:

- Computer control of all parameters
- Input - NRZ-L code and synchronized clocks
- Bit rate range - up to 1.2 Mbps
- Data Flow - MSB or LSB first
- Output - 16 bit parallel either MSB or LSB aligned
- Timing pulses - bit rate, syllable rate, frame rate
- Data ready signal.

3.7.3.2.1.5 Magnetic Tape Recorders

The analog magnetic tape recorders shall be the media in which the raw PCM data, voice, and timing information is stored. They shall meet the specifications of Ampex model FR 1900 or equivalent.

3.7.3.2.1.6 Front End Processor Interface Unit

The Front End Processor Interface Unit shall contain logic to interface the computer performing the telemetry data processing and command message formatting with the following:

- PCM Frame Synchronizer for telemetry data from NTTF
- Command Modulator (located at NTTF) for command messages
- NASCOM communication modem for telemetry data and command messages on remote site contact.

3.7.3.2.1.7 Time Code Generator/Translator and Interface

The Time Code Generator shall produce the required time codes to be used on analog magnetic tape recording, console display and data processing. The Ground Station time shall be supplied by the NASA GMT or analog tape playback and translated from BCD to binary for input to the PCC processing system. The interface unit shall provide the translated time code to the PCC computers in an acceptable format.

3.7.3.2.2 Command Control and Display Area

Spacecraft monitoring, analysis and control shall be performed in the Command Control and Display Area. It shall consist of five consoles under control of the central processing system. The consoles shall be designated as follows:

- Project Operations Console
- Ground Controllers Console
- Mission Planning Console
- Subsystem Console (2).

The central processing system shall provide the computing capability consistent with the requirements for PCC operation. The consoles shall provide the PCC personnel the ability to display and analyze Spacecraft data and initiate command execution.

3.7.3.2.2.1 PCC Processing System

The PCC Processing System shall be an on-line realtime computational facility consisting of high speed digital computers and associated peripherals. The computational capacity shall be sufficient to meet the following requirements:

- Accept downlinked telemetry data at the rate of 16K 8-bit words per second (onboard computer memory dump) or up to 4K 8-bit words per second (housekeeping data) for processing from the front end processor interface unit.
- Format and transmit command messages. Messages may be compiled and stored on disc or generated realtime by the PCC.
- Receive orbit definition data from the GSFC Orbit Determination facility.
- Provide the CDPF with ephemeris data required for payload data processing and receive User requests for use in mission planning.

The PCC Processing System shall support the realtime operating software required for efficient PCC operatic The following EOS-PCC operating system shall be provided:

- Attitude Determi tion Processor - A processor called by the ephemeris processor which determines the survival Observatory attitude, based on raw telemetry data and the current ephemeris.
- Real Time Command Processor - A collection of subprocessors used to implement the real time operator/analyst decision mode during a ground contact.
- On-Line Diagnostics - A collection of readily updated routines for the purpose of checking out the PCC.

- Contact Message Editor - A processor with extensive man workline interface used for reviewing, modifying and updating contact messages on the mission operation disk

- AOP Processor - A collection of subprocessors used for the purpose of ground checkout and updating of AOP routines.

- PCC SCPS Processor - Used to control all mission planning functions performed within the PCC, calls necessary routines, performs record keeping functions.

- Ephemeris Processor - Obtains results from the NASA/GSFC orbit determination group (orbital elements and associated ephemeris), and places this information on the PCC/IMS interface disk. The ephemeris processor also handles IMS requests for attitude data.

- Telemetry Processor - Converts the raw housekeeping data stream to engineering units, and routes the resulting values to storage.

- Data Compression - A processor which compresses the housekeeping data placed on the PCC history tape, as requested.

- Peripheral Processor - Formats housekeeping data for output to the described peripheral and performs routing functions as required. Provides necessary man/workline interfaces for housekeeping data analysis.

- Mission Operations Processor - A collection of subprocessors all of which are associated with executing the contact message as contained on the mission operations disk.

- GSFC SCPS Processor - Used to handle all of the functions required in interfacing with the centralized GSFC SCPS system.

- Spacecraft Scheduler - Used to plan and coordinate all Spacecraft housekeeping functions. These functions are fed into the appropriate SCPS activity via this scheduler, which can be called by the appropriate SCPS processor.

- Instrument Scheduler - Similar in overall function to the preceding processor, except that it is concerned with the payload instruments, and it has a heavy interface with the IMS system via the PCC/IMS buffer.

3.7.3.2.2.2 Console Specification

Each console in the PCC with the exception of the DOS console shall be of modular design with as much commonality as is feasible. Each console shall contain the following:

- Interactive alpha numeric CRT and keyboard

- CRT hard copy printer

- Digital cassette system

- Voice communication equipment
- Command control and display panel.

The interactive alpha numeric CRT display and keyboard shall be the major man-machine interface media. It shall display, in page form, any data required by the function of its console. It shall also allow for manual entry of data or commands into the system, via the keyboard. The flexibility of using this unit via software provides almost unlimited control over the function of a console in relation to the overall system. CRT interface characteristics shall conform to EIA RS-232C. The CRT hard copy printer shall provide the operator a means of obtaining a hard copy of the data currently being displayed on the CRT. CRT updating shall not be suspended during the hard copy printing. Impact type printing mechanism shall be avoided unless they are capable of quiet operation.

The digital cassette system shall be a dual cassette type, nominally 800 BPI with two tracks. The system shall be computer controlled with limited manual override capabilities.

The consoles shall contain standard voice communications equipment including telephone and intercom. The command control and display panel shall contain the following components:

- Event lite displays
- Digital readout analog displays
- CRT page selector switch
- Command switches.

The panel shall be completely computer controlled and therefore, no switch or display, with the exception of the CRT page selector shall be dedicated a specific function. The function of each display and switch shall be defined by the software program of the individual console. In order to provide a visual indication of the function of each display and switch an overlay shall be fitted to each command control and display panel. This overlay panel in conjunction with the software program shall define the display and command capabilities of the individual console. Some of the uses of the components of the command control and display panel are:

- Event Displays - Display of critical downlink event data from the Spacecraft, a means of alerting the operator to perform some task, etc.
- Analog Display - Display of critical downlink analog data from the Spacecraft.

- CRT Page Select - Select a particular page of data to be displayed on the CRT.

- Command Switches - Defined use virtually unlimited. Selection of snapshot programs. Selection of catalogued command sequences to be sent to the Spacecraft. Selection of specific software routines to be run.

The computer controlled Command Control and Display panel shall be designed to be extremely flexible with regard to configuration and function.

3.7.3.2.3 Peripheral Processing Area

The Peripheral Processing Area shall consist of equipment necessary for input or output of data to/from the computer system.

3.7.3.2.3.1 Magnetic Tape Transports

The Peripheral Processing Area shall contain four magnetic tape transports and associated controllers with the following minimum specifications:

- Tape width - 1/2 inch

- Tape speed - 45 inches per second

- Density - 800 characters per inch.

3.7.3.2.3.2 Card Recorder

The Peripheral Processing Area shall contain one 400 card per minute card reader.

3.7.3.2.3.3 Plotter

The Peripheral Processing Area shall contain one X-Y flatbed plotter, minimum 11 x 17 inch bed.

3.7.3.2.3.4 Printers

The Peripheral Processing Area shall contain two line printers - one for snapshot prints and one for event recording.

- Snapshot Printer - No. of columns - 132
  Speed - 1000 lines per minute

- Event Printer - No. of columns - TBD
  Speed - TBD

3.7.3.2.3.5 Teletype

The Peripheral Processing Area shall contain one Teletype Corporation Model ASR 35 or equivalent.

3.7.3.2.3.6 Strip Chart Recorders

The Peripheral Processing Area shall contain four 8-channel analog with interlaced event marker strip chart recorders and associated computer interface.

3.7.3.2.3.7 Disc Drives

The Peripheral Processing Area shall contain four disc drives and associated controllers.

Disc Specifications

TBD

3.7.4 LOCAL USER STATION

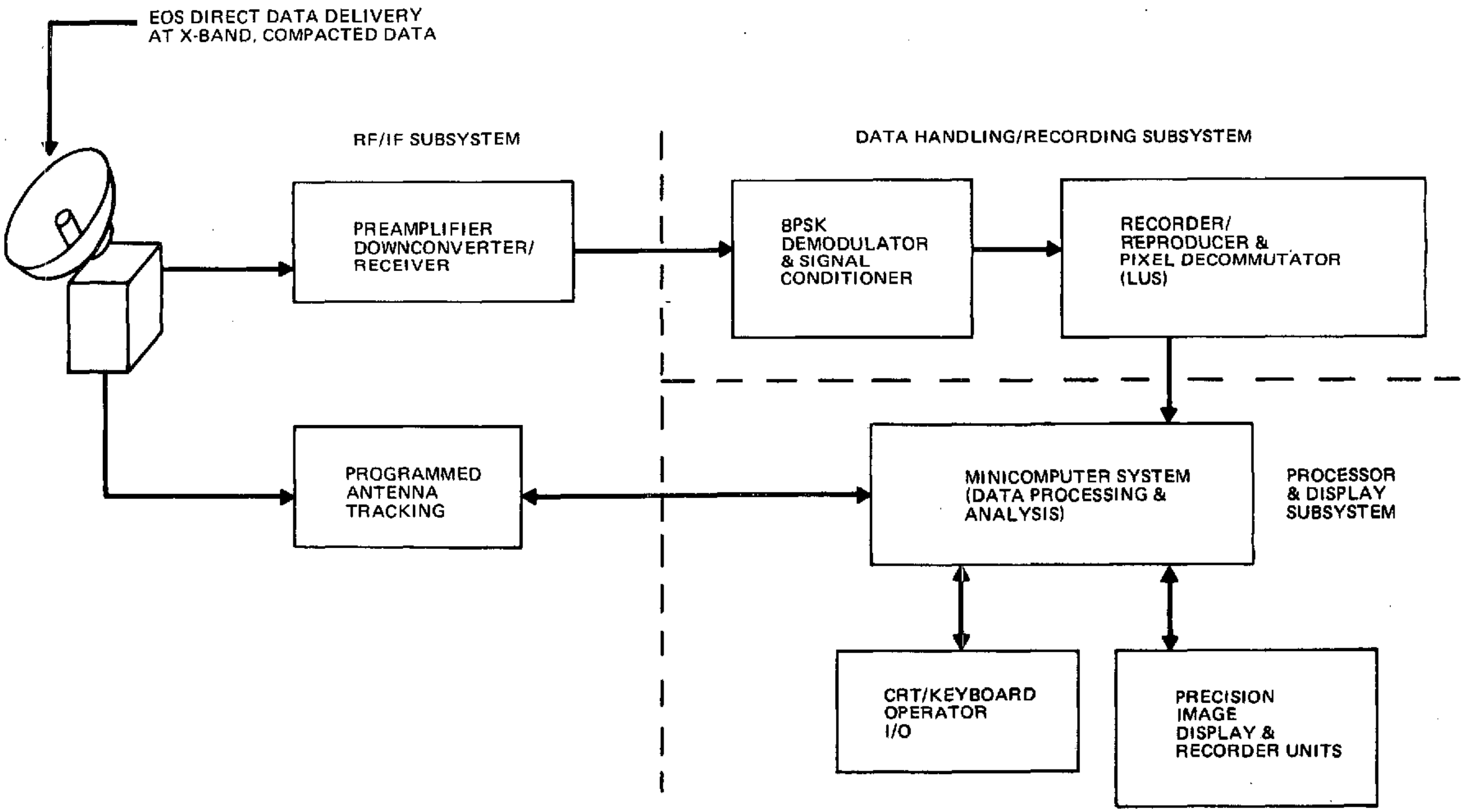
Figure 3-26 is an overall diagram of the LUS.

3.7.4.1 LOCAL USER STATIONS - RF/IF SUBSYSTEMS

The general performance characteristics for the overall terminals are given in Paragraph 3.2.1.4. Individual systems must meet the specifications to be given in this paragraph, but in addition must be consistent with the overall terminal characteristics. These terminals shall be engineered and produced as a system. An overall functional block diagram is given in Fig. 3-27.

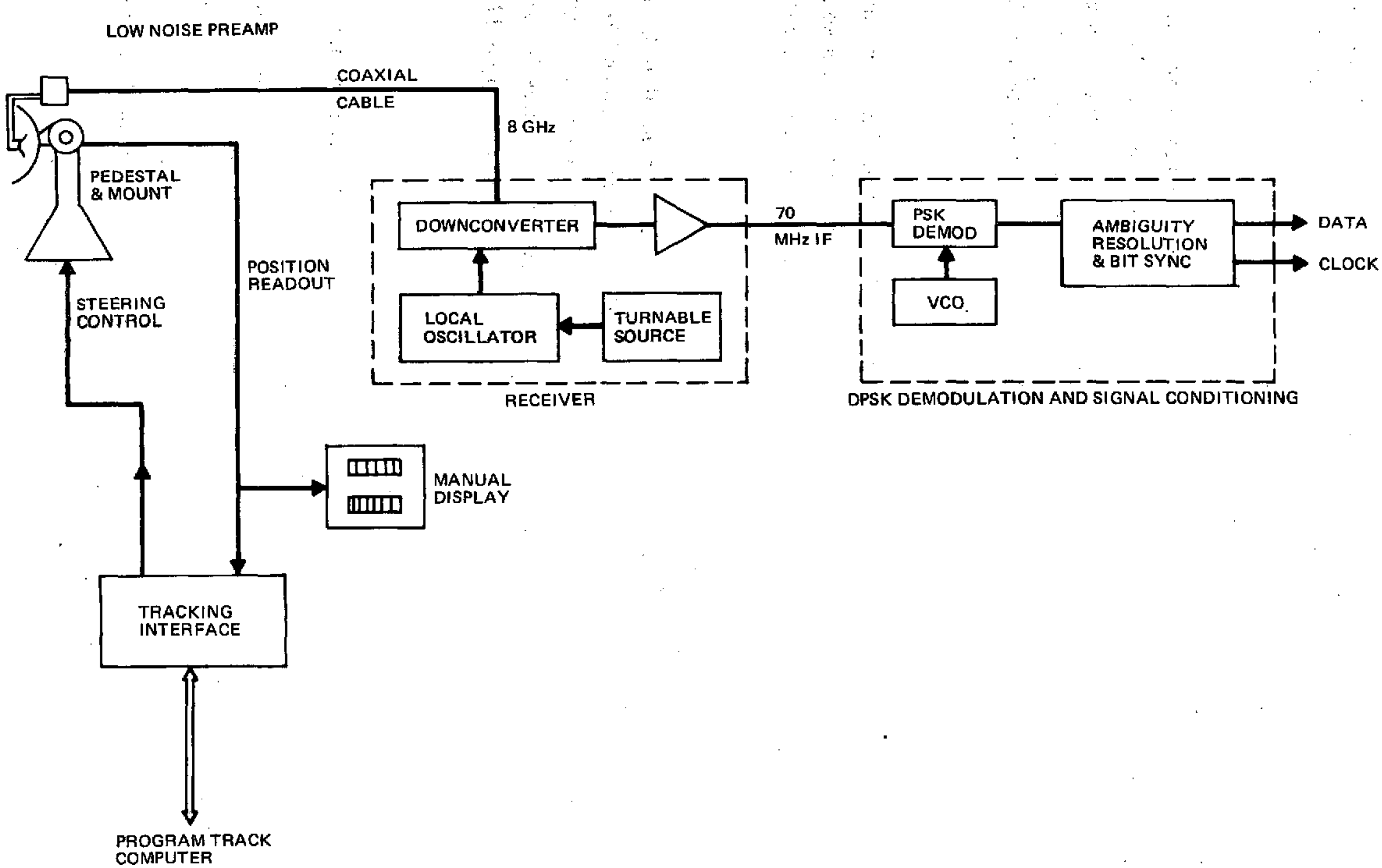
3.7.4.1.1 Antenna Subsystem

The antenna subsystem includes reflector, feed assembly, mount, steering and position readout. The basic receiving performance at 8.25 GHz shall be consistent with a G/T of 11 dB/^{o}K for the terminal, but in no case shall the reflector diameter exceed 4 meters. The antenna positioning system shall allow tracking without keyholes or discontinuities for all Observatory passes for which the subsatellite-point ground track comes within 500 Km of the terminal location. Such tracking shall be non-manual, except for initial acquisition positioning or for fallback or emergency operation, and programmed-track (open loop) is favored over autotrack. For programmed track operation, a servo and synchro interface unit shall be provided to allow the terminal computer to perform the tracking control. The antenna and mount should be constructed of lightweight materials, and their design should be amenable to cost reduction through mass production. However, the antenna system must be able to be installed without additional radome protection in exposed locations throughout the United States. The antenna system shall provide right hand circular polarization, and shall have an axial ratio of 1 dB or less. Manual position readout should be accurate to



(2)5-11

Fig. 3-26 Basic LUS Terminal Configuration



(2)5-12

Fig. 3-27 Local User Station

0.1Θ, and quantized (resolved) to $0.1\,\Theta$ where Θ is the half-power beamwidth of the antenna. Antenna steering, both manual and automatic, shall be consistent with these values. As stated above, the antenna positioning programmer (computer) is not a part of the antenna subsystem being specified herein.

3.7.4.1.2 Low Noise Preamplifier

The low noise preamplifier shall enable the overall receiving system to operate at the specified G/T, under the assumption that the antenna noise temperature is 40°K. For the range of antenna diameters under consideration, the preamplifier noise figure is thus expected to fall in the range 4 - 11 dB, with the lower end of the range favored. For optimum noise figure the preamplifier should be installed on or very near the antenna itself. The preamplifier parameters are summarized in Table 3-10.

3.7.4.1.3 Receiver Subsystem

The receiver/downconverter accepts the amplifier X-Band signal and translates to a 70 MHz intermediate frequency signal for input to the DPSK demodulator. It also provides signal level monitoring outputs for the operator's use and for possible acquisition/tracking assistance. Its characteristics are listed in Table 3-11.

3.7.4.1.4 Demodulator and Signal Conditioner

The LCGS demodulator shall process differentially-coherent phase shift keyed (DPSK) signals with a center frequency of 70 MHz and with data rates of 16 and 20 Mbps (selectable). Bit synchronization and ambiguity resolution shall be performed. The performance shall be within 1.5 dB of theoretical over the range of error rates $5 \times 10^{-6} \leq P_e \leq 10^{-2}$. These and other performance characteristics are listed in Table 3-12.

3.7.4.1.5 Test Equipment

Sufficient built-in test equipment shall be provided to:

- Test overall preamplifier and receiver sensitivity by means of injection of a weak (near threshold) X-Band signal.
- Test demodulator functions by means of a modulated signal with a predetermined data pattern. This signal may be generated and injected at IF.
- Check operating frequency.

These functions may be performed by specially designed and built equipment, or by standard, off-the-shelf signal generators, pattern generators, and the like.

Table 3-10 LCGS Low Noise Preamplifier Specifications

TYPE	FET PREFERRED
FREQUENCY	APPROX. 8.25 GHz (TO BE DETERMINED)
GAIN	30 dB
NOISE FIGURE	SEE TEXT
1 dB COMPRESSION LEVEL	−70 dB m
BANDWIDTH	50 MHz INSTANTANEOUS, MINIMUM *
GROUP DELAY	FLAT TO WITHIN 10% OF BIT DURATION OVER BANDWIDTH OF 0.55 TIMES THE BIT RATE
* AN OPTIONAL REQUIREMENT WILL BE TO ALLOW FOR SUFFICIENT BANDWIDTH OR RETUNING CAPABILITY FOR ANY OPERATING FREQUENCY IN THE 8.025 – 8.4 GHz BAND.	

(2)5T-9

Table 3-11 LCGS Downconverter/Receiver Subsystem

INPUT FREQUENCY BAND	8.025 – 8.4 GHz
NOISE FIGURE	12 dB
CENTER FREQUENCY TUNABILITY	10 kHz INCREMENTS OVER BAND
IF (OUTPUT) FREQUENCY	70 MHz
IF BANDWIDTH	30 MHz
OUTPUT	50 Ω COAXIAL
OUTPUT NOMINAL LEVEL	SEE DEMODULATOR SPECIFICATION (PARAGRAPH 3.7.4.1.4)

(2)5T-10

Table 3-12 LCGS DPSK Demodulator and Signal Conditioning Subsystem

MODULATION/DEMODULATION TYPE	DIFFERENTIALLY–COHERENT PSK
AMBIGUITY RESOLUTION	DIFFERENTIAL ENCODING OF DATA
PERFORMANCE	WITHIN 1.5 dB OF THEORETICAL
INPUT CENTER FREQUENCY	70 MHz
INPUT LEVEL	−20 TO −75 dBm
OUTPUT	DATA AND CLOCK
DATA RATES	16/20 MBPS
ACQUISITION PERFORMANCE	10 SECONDS NOMINAL
BIASED DATA PERFORMANCE	RUNS OF UP TO 15 ZEROS OR ONES CAN BE TOLERATED
OUTPUT:	
RISE AND FALL TIMES	⩽ 10 NS INTO 75 Ω ± 10% RESISTIVE LOAD
FREQUENCY UNCERTAINTY	± 5 kHz AT 70 MHz, AUTOMATICALLY SWEPT

(2)5T-11

3.7.4.2 HIGH DENSITY DIGITAL RECORDER

Each high density digital recorder (HDDR) shall meet the minimum requirement specified below.

- The HDDR shall be a high data rate recorder equipped with record and reproduce electronics suitable for high density PCM recording.
- The HDDR shall accept and record Serial NRZ-L input data at a 20 Mbps rate, and a coherent clock with a frequency of one full cycle per bit period. The on-line storage capacity of the HDDR at this input rate shall be a minimum of 15 minutes.
- The HDDR shall output Serial NRZ-L data at a 20 Mbps or slower rate, and a coherent clock with a frequency of one full cycle per bit period.
- The bit error rate (BER) experienced when reproducing data shall not exceed 1×10^{-6} when vendor recommended tape is used. This shall be true whether or not the tape is reproduced on the recording machine or on a different machine of the same type. The computation of bit errors shall include the effects of machine error, tape drop outs, and bit slippage due to both error sources.
- The record/reproduce speed ratio shall be 10:1 or greater with no degradation of the BER.
- The HDDR shall accept and record time-of-day information, thus referencing the input data to its recording time.
- All variation in the output data due to time base error (TBE), including wow and flutter, shall not exceed .01% deviation from the nominal value.
- The HDDR shall contain the means for monitoring the performance of each channel by some method such as the eye pattern. The eye pattern is generated by displaying the output of the reproduce preamplifier. The width of the eye is a qualitative indication of the SNR of a PCM system.
- The servo system shall use either an internal tachometer, or a prerecorded signal, a tape track as a reference, and shall switch reliably from one to the other.
- The life of the head assembly shall be 1000 hours or longer.
- Maintainability - The HDDR shall be designed and configured to permit early diagnosis of malfunctions, and rapid and easy replacements of faulty parts and/or subassemblies. The availability of the HDDR shall be $\geq .995$

$$\text{where availability} = \frac{\text{MTBF}}{\text{MTBF} + \text{MTTR}}$$

- The HDDR shall be provided with remote control and sensing capability for use by external equipment such as a computer. The remote control and status functions shall include, but shall not be limited to the following:

Control	Status
Power on/off	Power On
Speed Selection	Speed
Stop	Forward
Forward	Reverse
Reverse	EOT
Fast Rewind	Fault
Record	Tape Sync.
Reproduce	Loss of Data
Local/Remote	

3.7.4.3 LUS PROCESSING SUBSYSTEM

3.7.4.3.1 Central Processing Unit

The central processing unit (CPU) in the subsystem shall meet the following minimum requirements:

- The CPU shall be a high-speed processor with parallel arithmetic unit
- The CPU shall have hardware multiply/divide capability
- The CPU shall have hardware floating-point capability
- A real-time programmable clock shall be provided. This clock shall be under program control for use as either a pulse generator or an elapsed time counter.
- The processing unit shall have a multi-level indirect addressing feature or two or more index registers.
- The CPU shall have a power-safe feature that will detect an imminent failure of primary power and, with the aid of standard software, bring the unit to an orderly halt while power is still at sufficient level to permit reliable operation. Similarly, this feature shall sense the normal level of power and automatically cause the machine to resume execution of real-time programs at the point of prior interruption.
- The basic hardware instruction repertoire of the computer shall include, but not be limited to the following: loading and storing of register, arithmetic operations, logical and branching operations, and input-output operations.
- A control panel and/or console shall be provided for use by programmers or maintenance engineers to turn the system on, step through programs, display various status and error conditions, stop the programs and shutdown the system.
- The control feature shall have as a minimum, but not be limited to, the following:
  - Display storage words and register data
  - Start or stop instruction execution

- Address memory
- Interrupt of program manually
- Sequencing of each instruction
- Alarm indications for parity errors in core or in data channels, overflow condition and temperature overheat.
- Control to initiate built-in "bootstrap" loading of the computer.

- The priority interrupt system shall provide multi-level (or more) interrupts available to the programmer, each with its own unique priority. Hardware shall automatically handle and identify the priority.
- Each interrupt level shall be individually controllable to the extent that it can be:
  - Ignored by the processing unit
  - Remembered by the processing unit but not recognized
  - Recognized by the processing unit when it is the highest priority interrupt pending.
- Sufficient levels of priority interrupts, in addition to the multi-levels specified above, shall be provided to maximize the operating speed of all peripheral units.

3.7.4.3.2 Main Memory

The minimum requirements of the main memory shall be the following:

- The processing unit word length shall be at least 16 bits plus a parity. The memory shall be addressable and alterable by byte, word, or double word quantities
- A memory protection feature shall be provided
- The memory cycle time shall not exceed 0.8 microsecond
- The minimum size of the main memory will be determined by the requirements of the operating system, system software, application programs, size of working storage and temporary buffers
- The disk and magnetic storage units shall have an independent direct access to main memory.

3.7.4.3.3 Secondary Storage

The requirements for each storage device shall include the necessary controllers as attachments for connection to the CPU.

3.7.4.3.3.1 Magnetic Tape Units

Each magnetic tape unit shall have the following minimum capabilities:

- Recording on 7 or 9 track, 800 bits per inch, 10-1/2 inch tape reels, up to 2400 feet in length
- A tape speed of at least 45 inches per second with high speed rewind
- A minimum transfer rate of 30,000 characters per second.

3.7.4.3.3.2 Disk Storage Unit

Each disk storage unit shall meet the following minimum requirements:

- Each unit shall have removable packs or cartridges
- Each disk drive shall have a minimum storage capacity of 29×10^6 (twenty nine million) bytes
- A minimum data transfer rate of 2.5×10^6(2.5 million) bits shall be achievable
- The average access time for any data work shall not exceed 35 ms.

3.7.4.3.4 Input/Output

The input/output capabilities shall include, but not to be limited to, the following:

- Parity check whenever the programs and data are read from auxiliary storage
- The processing subsystem shall have the capability of transferring data in the word interrupt DMA or cycle stealing mode. The high-speed devices shall use cycle stealing mode for DMA while low-speed devices shall operate on word interrupt mode.

3.7.4.3.5 Peripherals

The peripheral equipment shall meet the following minimum requirements:

- All interconnections shall be provided, including the cables between the central processor and the peripheral units
- All peripherals shall be serviced through interrupts
- Direct access to memory shall be provided under program control
- The requirements for each peripheral device shall include the necessary controllers, cables or attachments for connection to the CPU.

3.7.4.3.5.1 Alphanumeric Keyboard/Printer Terminals

The following are the minimum requirements for the keyboard/printer terminals:

- The terminals shall be capable of operating as a normal typewriter
- The keyboard shall have the capability of being used off-line
- The terminals shall have a minimum speed of 10 characters per second.

3.7.4.3.5.2 Paper Tape Reader/Punch

The paper tape reader shall be capable of reading 8 channels of 1-inch perforated paper tape. The paper tape punch shall be capable of punching 8 channels on 1-inch paper tape. The reading and punching speeds are TBD.

3.7.4.3.6 CRT Terminal

Each CRT terminal used in the subsystem shall have a keyboard, buffered inputs as a storage screen. The screen size (diagonally) and lines and characters displaying capability are to be determined.

3.7.4.3.7 Initial Data Entry

The raw data from the acquisition system shall be entered on direct memory access (DMA) channel for temporary storage in the pre-assigned buffers in the main memory of the processing subsystem. The data shall follow a predefined character after a request of data entry is received by the subsystem.

3.7.4.3.8 Format and Record Arranging

The data rate entered into the subsystem shall be compatible with its data channel input rate. The input data format may be different from the one required by the subsystem during processing. In this case the subsystem shall transform the data into the format required for processing. Also, the data shall be arranged into records with each record representing one horizontal line of an image in the scene. Thus an image with 6168 horizontal lines will have 6168 corresponding records. The formating shall be done before storing the data temporarily in the pre-assigned buffers in main memory of the subsystem. Each record (data in one buffer) shall then be transferred to a secondary storage at a data rate compatible with the input rate of the secondary storage. The buffer thus emptied shall then be available for reuse by the input data stream or for any other use in processing. The formats for the LUS are defined in Fig. 3-28 through 3-32.

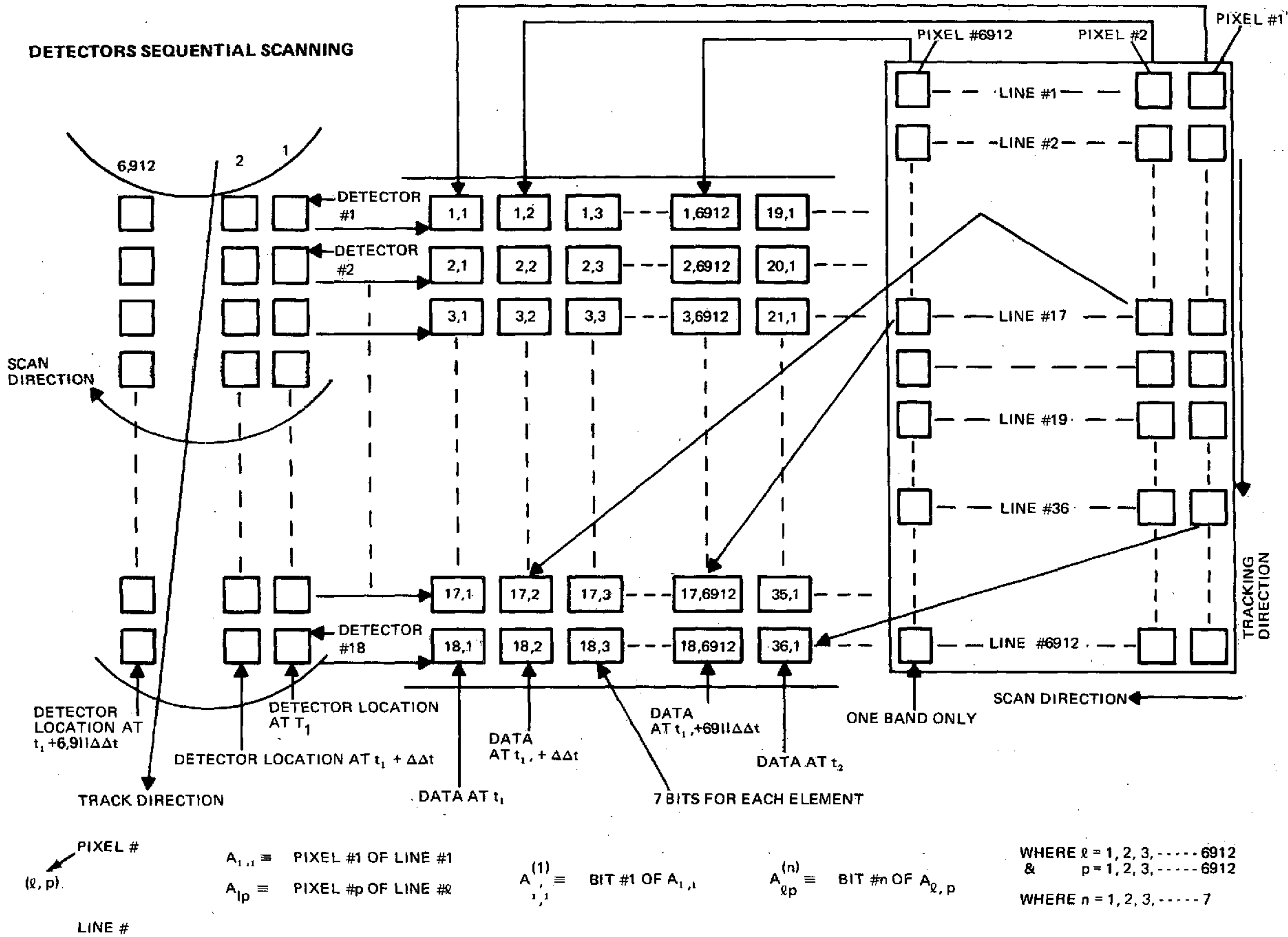


Fig. 3-28 Scanning Format

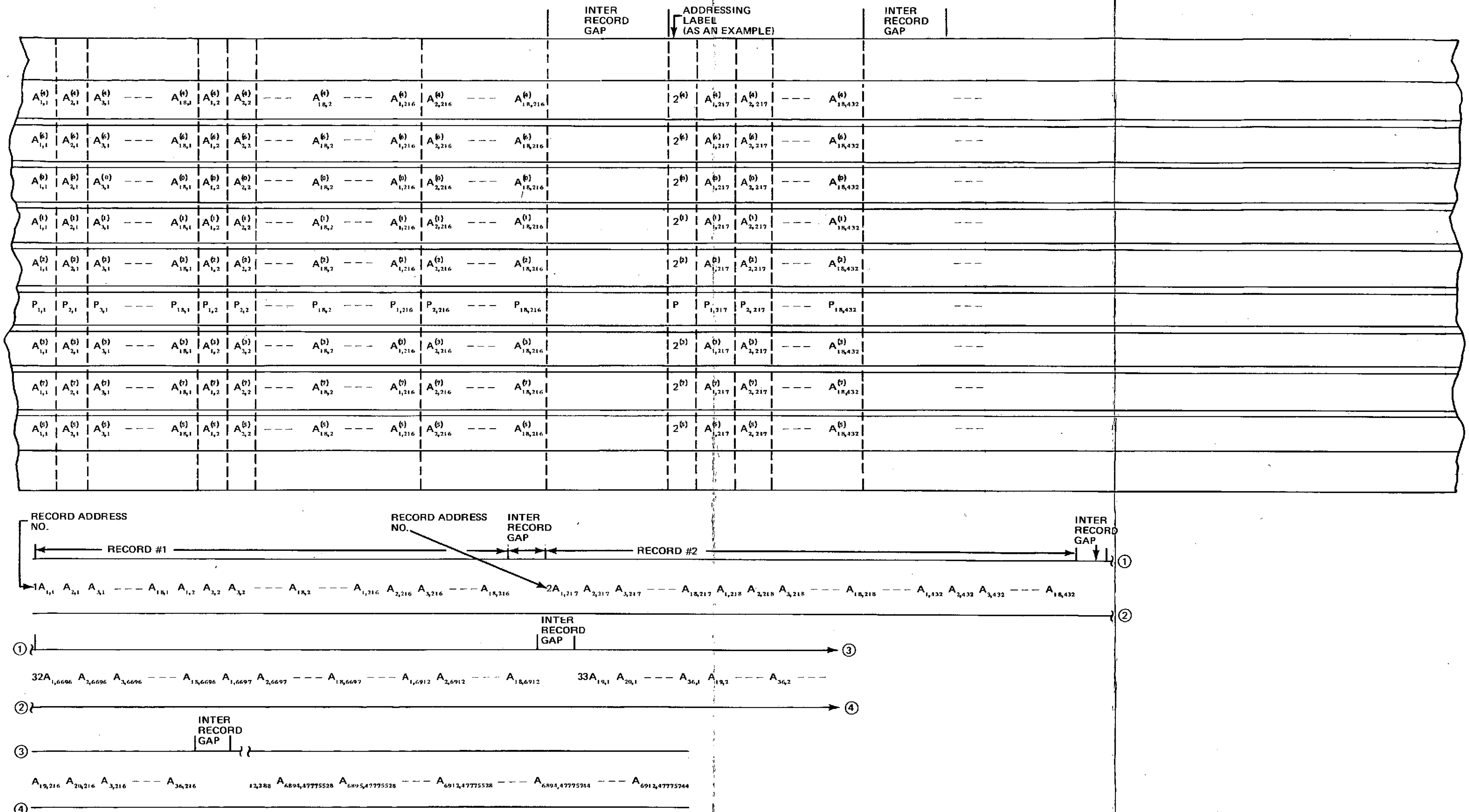
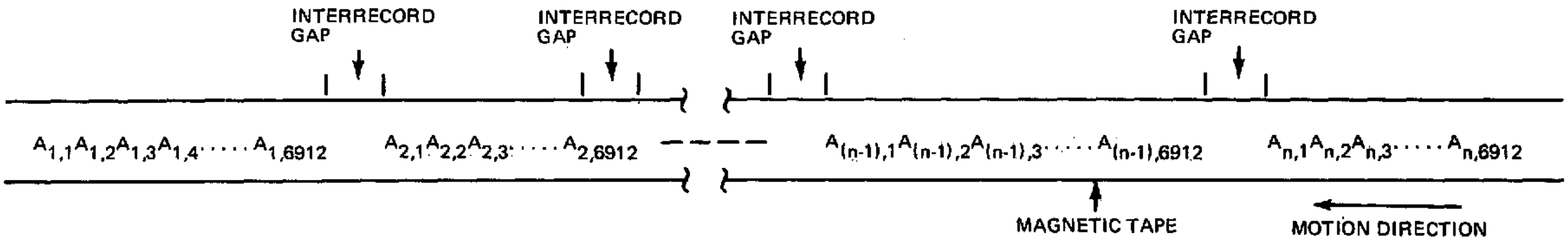


Fig. 3-29 Data Format on CCT Before Processing



$n = 1,2,3 \ldots ,6912$

$A_{1,1}$ = PIXEL #1 OF LINE 1

$A_{n,1}$ = PIXEL #1 OF LINE n

INTER RECORD GAP = 0.6"; TOTAL # OF RECORDS = 6912 = TOTAL # OF HORIZONTAL LINES IN ONE BAND

EACH RECORD STARTS WITH ADDRESS OR HEADER INFORMATION AND IS NOT SHOWN

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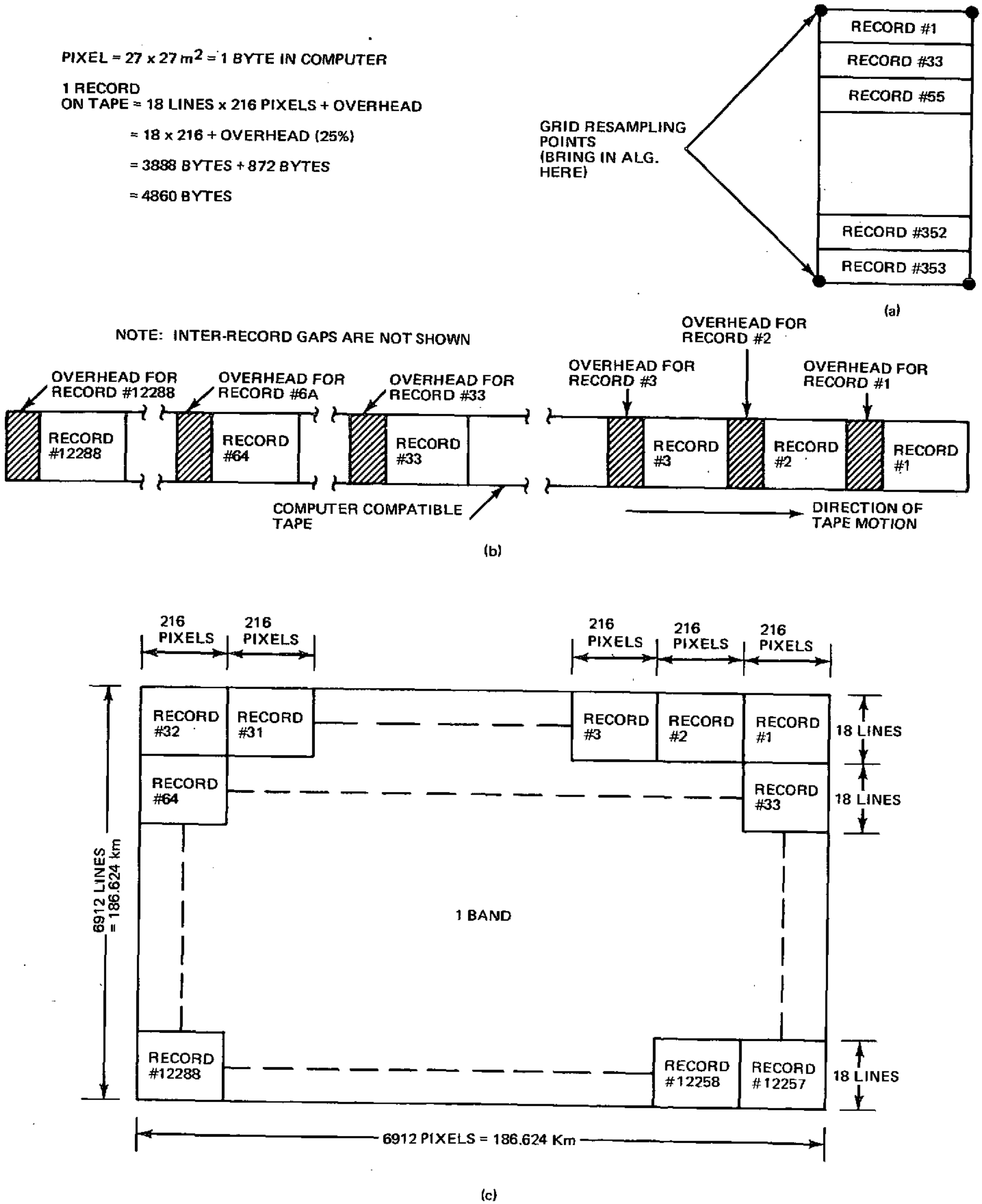
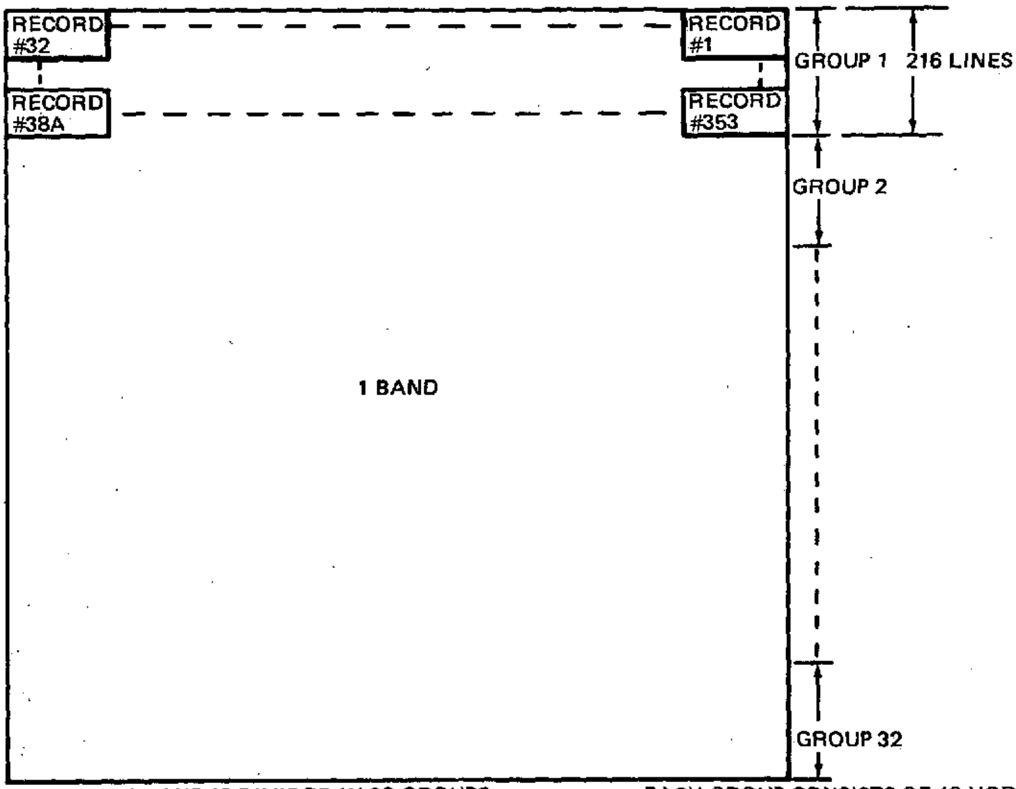
Fig. 3-30 Output Data Format on CCT or to Film Recorder



(2)5-25

Fig. 3-31 Input Data Format and Grid Resampling Scheme



NOTE: • 1 BAND IS DIVIDED IN 32 GROUPS
• EACH GROUP CONSISTS OF 384 RECORDS
• EACH GROUP CONSISTS OF 18 HORIZONTAL LINES AND 6912 PIXEL IN EACH OF 18 LINES

(2)5-26

Fig. 3-32 Band Subgrouping

3.7.4.3.9 Local Operator Control and Display

The subsystem shall recognize various requests from Users. The requests shall follow a predefined character. The requests may be for on-line image, off-line image, full image, or a selected part of image. The request may be for a hard copy (printed picture), display on CRT, negative or positive film (black and white or color), or computer compatible tape (CCT). All the off-line data shall be logged in the subsystem memory. For a request needing access to the off-line data, the subsystem shall print out an exact location of the data in library for an operator. For a CCT request, the subsystem shall store the processed data on the tape with standard inter-record and file gaps and appropriate end of file marks. The subsystem aided by its software shall provide negative or positive film (black and white or color), display the image data on CRT in proper format, or provide a hard copy when appropriate interface and subsystem is connected to the processing subsystem.

3.7.4.3.10 Monitoring of Other Subsystems of LUS

The subsystem shall have the capability of periodically monitoring the other subsystems such as display subsystems, acquisition subsystem connected to it. In the event a fault in the connected subsystem is detected, a message shall be printed out by the processing subsystem.

3.7.4.4 LUS CENTRAL SUPPORT SUBSYSTEMS

Two optional centralized support subsystems may be required that would be implemented within the CDPF. These are the Applications Program Development Laboratory (APDL) and the LUS Diagnostic and Equipment Laboratory (LDEL).

The APDL shall provide a computerized capability for the development of LUS Applications Programs and the conversion of previously developed programs for use with the LUSs. Additionally, scientific consultation services shall be available from the APDL personnel. Remote LUS processing and analysis equipment testing shall be provided by the LDEL via low-speed digital data dial-up telephone lines. The LDEL operators shall be experts with the operational LUS hardware and software and would be able to exercise the local computerized equipment via low-speed digital communications from their central location.

The applications and diagnostic support which is necessary to maintain operational LUSs shall be provided by the shared centralized system elements. Because the APDL and the LDEL are only optionally required based on the number of LUSs terminals to be implemented, further definition and performance requirements for the centralized LUS support subsystems will be supplied to the contractor when the LUS terminal implementation schedule is finalized.

3.8 PRECEDENCE

The order of precedence of contractual documents are the contract, this specification, and documents referenced in this specification. In the event of an apparent conflict among requirements stated within this specification or between requirements stated in this specification and other contractual or referenced documents, the contractor shall notify the procuring activity of the conflict and request resolution of the conflict.

Standards and specifications called for by this specification are mandatory for design and construction to the extent specified.

4 - QUALITY ASSURANCE PROVISIONS

4.1 GENERAL

The following analyses, inspections, demonstrations, and tests shall be conducted to verify compliance with the requirements of this specification. All verification results shall be documented and maintained with the particular GSE system logs.

4.1.1 RESPONSIBILITY FOR TESTS

The Contractor shall be responsible for the performance of all inspections, demonstrations, and tests as specified when approved by the procuring activity. The procuring activity reserves the right to perform any of the inspections set forth in this specification, where such inspections are deemed necessary to insure that the equipment furnished conforms to the prescribed requirements. The Contractor shall be responsible for all qualification tests specified herein including the maintenance, repair, support, and spare parts required to perform these tests. The Government is responsible for supplying qualified personnel to witness selected tests and to approve all test results prior to GSE system acceptance and delivery.

4.1.2 SPECIAL TESTS AND EXAMINATIONS

Previously qualified equipments procured from a qualified manufacturer need not be requalified; however, their suitability for use in the EOS GSE shall be tested.

Previc ly qualified equipments procured from a qualified manufacturer that have been functionally ›dified shall require CI/Subsystem testing to the degree necessary to establish the correct operation of the changed function and to establish that there has been no degradation in the performance capability of the remaining previously qualified functions.

4.1.2.1 NEWLY DEVELOPED EQUIPMENTS

Newly developed equipments shall require CI/Subsystem testing.

4.1.2.2 SYSTEM TEST

System testing is required for the system level design.

4.1.2.3 TEST FAILURE

In the event that the EOS GSE fails any test, the failure shall be corrected and the particular test shall be repeated until qualification has been achieved.

4.2 QUALITY CONFORMANCE INSPECTIONS

Quality conformance shall consist of the inspections, analyses, demonstrations, and tests specified herein. Methods of verification shall be those defined below:

- Inspection - verifies conformance of physical characteristics to related requirements without the aid of special laboratory equipments.
- Demonstration - verifies the required operability of hardware and computer programs, without the aid of test devices.
- Similiarity - verifies that the observatory components satisfy their performance and design requirements, based upon the certified qualification of similar components under identical or similar operating conditions.
- Analysis - verifies conformance to requirements, based upon studies, calculations and modeling.
- Test - verifies conformance to required performance/physical characteristics and design/construction by instrumented functional operation and evaluation techniques, including (where applicable) processing and/or handling of data sets prepared to simulate actual data. The testing shall be as defined in Table 4-1. (Only applicable tests are cited in the table. All other paragraphs do not have applicable tests.)

Table 4-1 Quality Conformance Inspection (Sheet 1 of 2)

PARAGRAPH	PROVISIONS	APPLICABLE TESTS				
		INSPECTION	DEMONSTRATION	SIMILARITY	ANALYSIS	TEST
3.1.2	EOS GSE GENERAL DESCRIPTION				X	
3.1.2.3	PAYLOAD DATA RECEPTION, RECORDING & HANDLING				X	
3.1.2.4	CDPF				X	
3.1.2.5	PCC				X	
3.1.2.6	LUS				X	
3.1.3	PROGRAM COST				X	
3.1.6.1	SPACECRAFT – PGS INTERFACE		X		X	X
3.1.6.2	PGS/TDRSS – CDPF INTERFACE		X	X	X	X
3.1.6.3	CPS – PCC INTERFACE		X		X	X
3.1.6.4	CDPF – USERS INTERFACE		X		X	X
3.1.6.5	CPS – PHOTO LAB INTERFACE		X	X	X	X
3.1.6.6	INITIAL CPS – FINAL CPS INTERFACE				X	
3.1.6.7	SPACECRAFT – LUS INTERFACE		X		X	X
3.1.6.8	LUS – USER INTERFACE		X			X
3.1.6.11	STDN TRACKING, TELEMETRY & COMMAND INTERFACE		X	X	X	X
3.2.1	PERFORMANCE		X	X	X	X
3.2.1.1	PAYLOAD DATA RECEPTION, RECORDING & HANDLING		X	X	X	X
3.2.1.2	CDPF		X	X	X	X
3.2.1.2.3	OUTPUT PRODUCT QUALITY				X	X
3.2.1.2.4	THROUGHPUT AND TURNAROUND					X
3.2.1.2.5	DATA PRODUCT QUANTITIES		X	X		X

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Table 4-1 Quality Conformance Inspection (Sheet 2 of 2)

PARAGRAPH	PROVISIONS	APPLICABLE TESTS				
		INSPECTION	DEMONSTRATION	SIMILARITY	ANALYSIS	TEST
3.2.1.2.6	ARCHIVE		X	X		X
3.2.1.2.7	ISS FUNCTIONS		X		X	X
3.2.1.3	PCC		X	X	X	X
3.2.1.4	LUS		X	X	X	X
3.2.2	PHYSICAL CHARACTERISTICS RELIABILITY, AVAILABILITY, AND MAINTAINABILITY	X				
3.2.3.1	CPS		X			X
3.2.3.2	PAYLOAD DATA RECEPTION; RECORDING & HANDLING		X			X
3.2.3.3	PCC				X	
3.2.4	GSE SYSTEM ENVIRONMENT		X	X		X
3.3	DESIGN AND CONSTRUCTION	X		X		
3.3.1	EQUIPMENT	X		X		
3.3.2	COMPUTER PROGRAMMING	X		X		
3.4	DOCUMENTATION	X		X		
3.5	LOGISTICS	X	X	X	X	
3.5.1	CPS		X		X	
3.6	PERSONNEL & TRAINING				X	
3.7	FUNCTIONAL AREA CHARACTERISTICS	X	X	X	X	X
3.7.1	DATA RECEPTION, RECORDING, & HANDLING	X	X	X	X	X
3.7.2	CPS				X	X
3.7.2.1	OUTPUT PRODUCT QUALITY					
3.7.2.2	PROCESSING				X	
3.7.2.3	INTERPOLATION ALGORITHMS				X	
3.7.2.4	INFORMATION SERVICES SYSTEM		X	X	X	X
3.7.2.5	OUTPUT PRODUCT GENERATION		X	X		X
3.7.2.6	ARCHIVE		X	X		X
3.7.3	PCC		X			X
3.7.4	LOCAL USER SYSTEM		X	X	X	X

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5 - PREPARATION FOR DELIVERY

EOS Ground Segment Equipment shall be packaged for delivery to conform to Level C, MIL-STD-794B, March 1969. Marking for shipping and storage shall be in accordance with MIL-STD-129.

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